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LOS ALAMOS NATIONAL LABORATORY
1998 ENVIRONMENTAL STEWARDSHIP ROADMAP

by

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This Roadmap is certified, along with the 1997 Site Pollution Prevention Plan (LA-UR-97-1726), to satisfy the requirements of 40CFR264.73.B9 (RCRA).

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EXECUTIVE SUMMARY

Los Alamos National Laboratory (LANL or Laboratory) has a goal of zero environmental incidents. The Environmental Stewardship Program coordinates Laboratory efforts to eliminate the sources of environmental incidents. Good stewardship eliminates these sources through waste minimization, pollution prevention, and conservation improvements that move the Laboratory toward zero waste, zero pollutants released, zero natural resources wasted, and zero natural resources damaged. The fundamental assumption of the Environmental Stewardship Program is that good stewardship not only protects the environment, it pays for itself in reduced costs. Furthermore, it minimizes waste- and pollution-related work, enabling staff to devote more time to Laboratory missions. Good stewardship and reducing the sources of environmental incidents are the responsibility of every person working on the site.

This document summarizes the Laboratory's roadmap for Environmental Stewardship. It describes current operations, improvements that will eliminate the sources of environmental incidents, and the endstate that is the goal. This is the 1998 version of the roadmap. It is an amendment to the Laboratory's Site Pollution Plan and is certified, along with that plan, to satisfy the requirements of 40CRF264.73.B9 (Resource Conservation and Recovery Act). This version of the roadmap summarizes a systems analysis of Laboratory operations and focuses on waste generation and waste minimization. Future versions will add the analysis necessary to reduce the Laboratory's potential pollutant streams and natural resource usage.

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ACRONYM AND ABBREVIATION LIST

ACIS	Automated Chemical Inventory System
ANSI	The American National Standards Institute
ARIES	Advanced Recovery and Integrated Extraction System
APT	Accelerator Production of Tritium
BUS	Business Operations Division
CFR	Code of Federal Regulations
CHEAPER	Chemical Exchange Assistance Program and External Recycle
CIC	Computing, Information, and Communications (Division)
CMR	Chemical and Metallurgical Research (Facility)
CST	Chemical Science and Technology (Division)
CY	Calendar Year
D&D	Decontamination and Decommissioning
DOE	Department of Energy
DOE/AL	Department of Energy/Albuquerque Operations Office
DOE/DP	Department of Energy/Defense Programs
DOE/EM	Department of Energy/Environmental Management
DOE/GSA	Department of Energy/General Services Administration
DP	Defense Program
DSSI	Diversified Scientific Services, Inc.
DU	Depleted Uranium
DVRS	Decontamination and Volume Reduction System
DX	Dynamic Experimentation (Division)
EM	Environmental Management
EM/SWO	Environmental Management/Solid Waste Operations (Group)
EMS	Environmental Management System
EPA	Environmental Protection Agency
ER	Environmental Restoration
ESA	Engineering Sciences and Applications (Division)
ESH	Environment, Safety, and Health (Division)
ESO	Environmental Stewardship Office
FE	Fossil Energy (Division)
FFCO/STP	Federal Facility Compliance Order/Site Treatment Plan
FMU	Facility Management Unit

FY	Fiscal Year
GIC Facility	Green Is Clean Facility
GSAF	Generator Set-Aside Fee

ACRONYM AND ABBREVIATION LIST (cont)

INEEL	Idaho National Energy and Environmental Laboratory
ISM	Integrated Safety Management
JCNNM	Johnson Controls Northern New Mexico
JIT	Just In Time
LANL	Los Alamos National Laboratory
Laboratory	Los Alamos National Laboratory
LANSCE	Los Alamos Neutron Science Center
LLNL	Lawrence Livermore National Laboratory
LLW	Low-Level (Radioactive) Waste
MBA	Material Balance Area
MEO	Mediated Electrochemical Oxidation
MLLW	Mixed Low-Level Waste
MRF	Metal Recovery Facility
MTRU	Mixed Transuranic
NASA	National Aeronautics and Space Administration
NDA	Nondestructive Assay
NMED	New Mexico Environment Department
NMT	Nuclear Materials Technology (Division)
NPDES	National Pollutant Discharge Elimination System
NRC	Nuclear Regulatory Commission
ODS	Ozone Depleting Substance
PCB	Polychlorinated Biphenyl
PMR	Palladium Membrane Reactor
PNNL	Pacific Northwest National Laboratory
PPE	Personnel Protective Equipment
PVA	Polyvinyl Alcohol
PVC	Polyvinyl Chloride
R&D	Research and Development
Rad	Radioactivity
RANT	Radioassay and Nondestructive Testing
RCA	Radiological Control Area
RCRA	Resource Conservation and Recovery Act
RLWTF	Radioactive Liquid Waste Treatment Facility

ROI	Return on Investment
SNM	Special Nuclear Material

ACRONYM AND ABBREVIATION LIST (cont)

STL	Safeguards Termination Limit
SWB	Standard Waste Box
SWSC	Sanitary Wastewater System Consolidation
SWEIS	Sitewide Environmental Impact Statement
SWO	Solid Waste Operation
TA	Technical Area
TBD	To Be Determined
TCLP	Toxic Characteristic Leaching Procedure
Tonne	Metric Ton
TRU	Transuranic
TSCA	Toxic Substances Control Act
TSDF	Treatment, Storage, and Disposal Facility
UC	University of California
WAC	Waste Acceptance Criteria
WCRRF	Waste Compaction, Reduction, and Repackaging Facility
WIPP	Waste Isolation Pilot Plant
WM	Waste Management
Z	Atomic Number

1.0. INTRODUCTION

1.1. Laboratory Environmental Goals

Los Alamos National Laboratory (LANL) has two major environmental excellence goals: zero environmental incidents and zero Resource Conservation and Recovery Act (RCRA) violations. The strategy for achieving these goals has two elements. First, the Laboratory will comply with all applicable environmental laws, regulations, Department of Energy (DOE) Orders, and consensus standards. Compliance is managed through the Laboratory's Integrated Safety Management System. Environment, Safety, and Health (ESH) Division assists Laboratory divisions in planning and maintaining compliant operation. Second, the Laboratory will continue to execute its prevention-based Environmental Stewardship Program that seeks to eliminate the potential for environmental incidents and RCRA violations from Laboratory operations. Stewardship is managed by the Environmental Management (EM) Environmental Stewardship Office and is based on a systems understanding of Laboratory operation. The Stewardship Program is summarized by an environmental stewardship roadmap. This document is the 1998 version of that roadmap.

The stewardship solution for zero incidents and RCRA violations is to eliminate their source. This is accomplished by continuously improving operations to achieve

- zero waste,
- zero pollutants released,
- zero natural resources wasted, and
- zero natural resources damaged.

Zero waste means continuously improving the planning, design, and operations processes such that the transuranic (TRU) waste, mixed low-level waste (MLLW), low-level (radioactive) waste (LLW), hazardous waste, and sanitary waste generation are reduced continuously and approach zero. In cases where the Laboratory's programmatic workload increases (and causes increased waste generation), the Laboratory will continue to reduce waste from the increased levels.

Zero pollutants released means improving operations such that only benign substances are released to the environment through gas emissions, effluent releases, or solids dispersal. It also means improving operations continuously such that the potential for releasing pollutants is reduced continuously. Ozone-depleting chemicals and greenhouse gases are examples of nonbenign substances.

Zero natural resources wasted means achieving best-practice operation such that a minimum of electricity, natural gas, and water is consumed. It also means

(1) optimizing program and support activities so that a minimum amount of equipment and materials is procured and (2) ensuring that equipment and materials with a maximum of recycled content are preferentially procured. It further means that the Laboratory eliminates procurement of products where the manufacture causes significant environmental damage.

Zero natural resources damaged means respecting the local ecosystem by not interfering with its natural processes. In some cases, controlled burns for example, it may be necessary to manage natural processes; however, in most cases, the ecosystem should be left to manage itself.

The preceding are design and continuous improvement goals. They define the stewardship solution for achieving zero incidents and RCRA violations.

There are several other regulatory and programmatic drivers for these stewardship goals:

- Productivity and Competitiveness. The cost of waste, environmental monitoring, and environmental controls are nonproductive costs; they reduce the value the Laboratory offers the nation for each dollar of funding received. In fiscal year (FY) 00, programs will pay their total waste disposal costs through a Laboratory recharge account. Minimizing waste expenses will directly reduce programmatic cost to sponsors.

- Environmental Competitiveness. Over time, the government laboratory that can perform its work with the least damage to the environment will develop an environmental advantage. Least damage to the environment relates to the concept of environmental sustainability, which is defined to be operating today such that the options of future generations are preserved.

- Executive Directives. Several new pollution prevention and energy conservation executive orders and secretarial goals have been published or are expected. EO 13101, dealing with the purchase of products with recycled and renewable materials content, was published September 14, 1998. On December 12, 1998, the Secretary announced a departmental goal of replacing all pre-1984 chillers using ozone depleting chemicals by 2005. The stewardship goals and roadmap proactively anticipate these requirements.

- DOE 2005 Pollution Prevention Goals. In 1996, the DOE established pollution prevention goals for 1999. In 1999 (Earth Day), the DOE is expected to establish a new set of goals for 2005. These probably will include a 50% reduction in all routine waste, a 50% reduction in use of priority toxic chemicals [as defined by the Environmental Protection Agency (EPA)], recycling of 50% of the solid sanitary waste, use of 5% of renewable energy sources, 30% reduction in water use, and several more goals. It is likely that another set of follow-on goals will be published in 2005. Pursuing the stewardship solution puts the Laboratory ahead of percentage reduction goals.

- Environmental Regulation. Historically, environmental laws, regulations, and interpretations of regulations have become stricter. Operating to the limits of compliance would leave the Laboratory vulnerable to the vicissitudes of regulations and regulators.

- Site RCRA Permit Waste Minimization Plan Requirement. The RCRA statue, as implemented in the site's RCRA operating permit, requires that the site have a waste minimization plan. The stewardship goals and the roadmap summarizing the Laboratory's approach toward those goals partially satisfy this requirement.

1.2. Environmental Stewardship

The environmental stewardship goals are being accomplished by two complementary actions. First, individuals across the Laboratory are evaluating their operations and making process improvements that reduce the possibility of impacting the environment. A significant fraction of the Laboratory's recent waste minimization success is the result of many small improvements instituted by individuals doing the right thing. Second, the Stewardship goals are being accomplished through an organized, Labwide Environmental Stewardship Program. This program organizes metrics for environmental aspects and impacts and implements sitewide opportunities for reducing them. Both the actions of individuals and the Labwide program are necessary to achieve the Stewardship goals.

The stewardship zero goals need not be achieved all at once or in a particular order. They can be accomplished in ways that make sense in the context of Laboratory missions, budgets, and existing plans. Certain implementation principles have proven effective for other organizations and have been incorporated into the Laboratory's program:

1. establish a systems framework for environmental aspects (potential for environmental impact) and impact,

2. rank positive return-on-investment (ROI) improvements first,

3. rank improvements based on the quantitative magnitude of their aspects and impact, and

4. rank improvements based on their pollution prevention value (according to the pollution prevention pyramid. This ranks waste minimization solutions on a spectrum: source avoidance, material substitution, internal recycle, lifetime extension, segregation of wastes, external recycle/reuse, volume reduction, waste treatment, and disposal. Source avoidance is the best-, disposal is the least-valued solution.).

Based on these principles, the Laboratory's Stewardship Program will generate savings from initial improvements that can fund subsequent improvements. It will address the most significant environmental aspects and impacts first. It will stress improvements that minimize the consumption of energy and materials—minimizing consumption precludes the generation of byproducts, waste, or pollution that must be recycled, treated, or disposed of.

The Laboratory's Environmental Stewardship Program has incorporated these principles into the Environmental Stewardship Roadmap. A roadmap is a logical construct that identifies and quantifies the issues and decisions between the present state (how the Laboratory operates today) and an endstate.

The endstate is described by the four stewardship goals. The present state is summarized by a Pareto analysis that quantifies and ranks the Laboratory's environmental aspects and impacts. (A Pareto analysis develops the information necessary to identify the most important impacts; it enables the program to know how to take a graded approach.) Impacts include waste generation, effluents, air emissions, energy usage, water usage, materials procured, etc. These impacts again are Pareto analyzed to identify the largest waste streams for each waste type, the largest energy users, the largest water users, etc. Waste streams are analyzed using process maps; maps identify the sources of waste (the environmental aspects). Improvement options are developed that reduce or eliminate the waste stream. Improvement options are analyzed for investment cost, ROI, waste-avoidance type (ranking on the pollution prevention pyramid), and other issues. The highest ROI improvements, which rank highest on the P2 pyramid, are analyzed for the best funding mechanism. Funding is sought. Neither the Laboratory nor DOE has identified appropriated funding for Environmental Stewardship. Improvement funds are coming from mission programs, institutional reinvestment funds, indirect funds, Landlord funds, and special funding opportunities. As improvement options are implemented, the roadmap is updated and the improvements are incorporated into the present state description.

The Pareto principle and a graded approach are at the heart of stewardship and are reflected in the roadmap. This 1998 roadmap version focuses on the most significant environmental impacts. Eliminating these does not take the Laboratory to zero waste—just 80% of the way. As these most significant impacts are eliminated or put on a track for elimination, future versions of the roadmap will address the next most significant environmental impacts. This roadmap summary will be revised and expanded annually.

The “graded approach” has one more dimension that warrants discussion. Grading usually means addressing the most significant elements first. In this case, “graded” also means emphasizing improvement options that require the minimum effort from Laboratory staff. This kind of “graded” means providing most environmental-choice information right when it is needed, rather than requiring people to remember data from training courses. It means building environmental protection into the design of operations and processes, rather than requiring individuals to know how to choose between actions with different environmental aspects. People produce the Laboratory’s products. The more time those people spend managing environmental impacts, the less time that is available to produce mission products and to enhance their scientific and mission skills. In summary, the graded approach means addressing significant aspects, significant impacts, and the biggest cost savings first, as well as minimizing the staff time required to do both.

The stewardship goals and the roadmap focus on the local environmental impact and the need for improvements. The total, integrated, and worldwide environmental impact of LANL is overwhelmingly positive. Nuclear weapons have been a successful tool in the prevention of major wars and their concomitant environmental damage. The Laboratory’s science has contributed to technological advances, enabling the production of products that have reduced environmental impact nationwide and worldwide. The Laboratory’s environmental models and computer simulations have improved global understanding of the links between anthropogenic activities and environmental damage. Laboratory technologies such as the Advanced Recovery and Integrated Extraction System (ARIES) and Accelerator Production of Tritium (APT) will enable other DOE sites to reduce their environmental impacts as they accomplish their DOE defense missions. This roadmap focuses on the environmental impact of our site operations—this is the local environmental cost of our science, technology, and mission accomplishments. The roadmap seeks to illuminate how we can reduce this environmental cost without sacrificing our scientific quality, productivity, or value to the nation.

1.3. The Laboratory: A System of Material and Energy Flows

1.3.1. The Laboratory Process Map

To the environment, the Laboratory is just another subsystem—probably a young and immature one compared to the other ecosystems on the Pajarito Plateau. Figure 1-1 shows the Laboratory process map, which is a view of the Laboratory from the local environmental perspective. Not shown, but also important, is the regional environmental impact related to Laboratory operations.

1.3.2. Inflows

The Laboratory receives funding and mission assignments from the DOE. Through the DOE it also performs work for other government sponsors and private industry. To accomplish these assignments, the Laboratory procures services, materials, equipment,

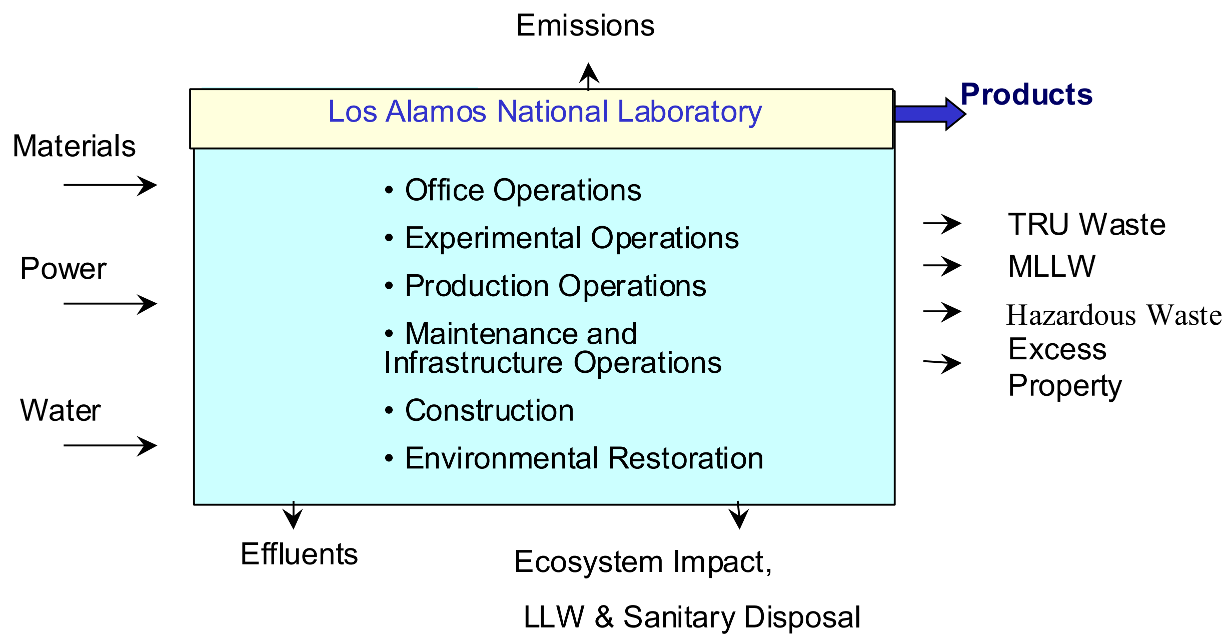


Fig. 1-1. Laboratory process map.

new facilities, and commodities (electricity and natural gas). The Laboratory also takes in water from the regional aquifer and air from the surrounding atmosphere. Figure 1-1 shows the substance and energy inflows to the Laboratory. The DOE directives and good business practice require that the Laboratory procure these inflows at the most competitive purchase price. Recent federal guidance (EO 13101) requires that the Laboratory also consider the environmental impact of procurement choices; however, procurements selections currently are determined by price-competitiveness and product-quality considerations. The stewardship goals require that the Laboratory consider the life-cycle cost, as well as the environmental impact of their production. In many cases, the same product does not have the minimum purchase price and minimum life-cycle cost. For example, purchasing a standard container of a hazardous chemical when only a small fraction of that container is required results in the excess being disposed of as hazardous waste at a cost many times greater than the chemical purchase price.

1.3.3. Operations

Once in the Laboratory, the inflows are used in the six different kinds of operations listed in Fig. 1-1.

Most University of California (UC) and subcontractor person-hours are spent conducting office operations. These involve office space, furniture, information processing equipment, paper, and office supplies. Energy is expended to operate equipment and provide climate control. Water is used in evaporative cooling to transfer waste heat to the atmosphere.

Experimental operation includes bench-scale research, experiments at LANSCE, criticality experiments at Technical Area (TA)-18, explosive tests at Dynamic Experimentation (DX) Division firing sites, and fabrication of the experimental hardware used in experiments. Inflows include facility construction and modification, a variety of chemicals and materials (but typically in small volumes), diagnostic equipment, and small-scale processing equipment. Energy is expended to operate the equipment and provide climate control. Water is used in evaporative cooling to remove waste heat. Experimental operations typically procure large amounts of equipment but small amounts of chemicals. These operations consume over half of the energy used on site (especially LANSCE), and because almost 100% of that energy is converted to waste heat, they consume a significant fraction of the water used on site.

Production operations include Nuclear Materials Technology (NMT) Division plutonium processing and production operations. They also include NMT analytic chemistry operations at the Chemical and Metallurgical Research (CMR) Facility. Most of the Laboratory's TRU waste and almost half of the LLW are generated during production operations. Energy and water usage is modest.

Maintenance and infrastructure operations include all Johnson Controls Northern New Mexico (JCNNM) maintenance activities, Facility Management Unit maintenance activities, and sitewide infrastructure systems, such as the solid waste operation (SWO) (TA-54), Radioactive Liquid Waste Treatment Facility (RLWTF) (TA-50), power plant, SWSC waste water plant, water influent system, and highway system. These consume large quantities of chemicals and produce most of the site's hazardous waste. They also consume significant amounts of energy and water, especially the power plant.

Construction includes both smaller construction projects performed by JCNNM and major construction projects conducted by competitively selected contractors. The Laboratory will spend $1.2 billion on construction over the next 10 years. Construction upgrades in nuclear facilities could be the largest radioactive waste generators during the next 5 years. Construction operations are not only important as a source of immediate environmental impact during construction activities; design decisions made during the construction process can lock in environmental impact for the lifetime of the facility.

Environmental Restoration (ER) includes all DOE/Environmental Management (EM)-40 activities on the site. There is significant radioactive and hazardous material buried in old material disposal areas. Many of the canyons are contaminated from past operations that released radioactive and hazardous effluents directly to the environment. These are being stabilized and cleaned up by the ER Project. This should be completed by 2010. To the extent that contaminated media must be removed and transferred off site, the ER Project could be the largest waste generator on site. However, because ER waste is typically very dilute and managed in large volumes, the ER cost for wastes is much less than the costs paid by other operations. For the purpose of this roadmap, ER Project waste is not considered newly generated waste and is not included in the Pareto analysis. It cannot be prevented, only minimized. The roadmap and the Stewardship Program focus on the Laboratory's future environmental impact long after the effects of past operation have been remediated. The ER Project has its own waste minimization plan and processes.

One other operation that is a significant waste source (but that is not listed in the figure) is the EM Legacy Waste Program. Both MLLW and TRU waste have accumulated because there have been no disposal options. These wastes are stored at TA-54. In the past 2 years, much of the MLLW has been transferred to commercial disposal vendors. TRU waste will be sent to the Waste Isolation Pilot Plant (WIPP) once it opens. As with the ER Project wastes, legacy wastes cannot be prevented, only minimized. They also are not included in the roadmap. SWO (at TA-54) has several initiatives underway to minimize legacy waste.

1.3.4. Outflows

Because the Laboratory's products are mostly information, most material inflows become byproduct or waste outflows. Consequently, both consumption and waste generation reflect the Laboratory's inefficiency. Outflows are divided into the eight categories listed in Fig. 1-2. TRU waste, MLLW, LLW, hazardous waste, and solid sanitary waste are well defined and discussed in detail later in this document. Excess property includes all items processed through the Business Operations Division (BUS)-6/JCNNM salvage system. Most of these items are reused or recycled. Effluents include all of the waste water released from the site into the canyons. Two-thirds of the water brought on site is discharged through outfalls. The remaining one-third is released to the atmosphere as water vapor from cooling towers. Emissions have four components. Greenhouse gases are released from combustion (primarily the power plant, building heating systems, and Pajarito water pump). Residual amounts of

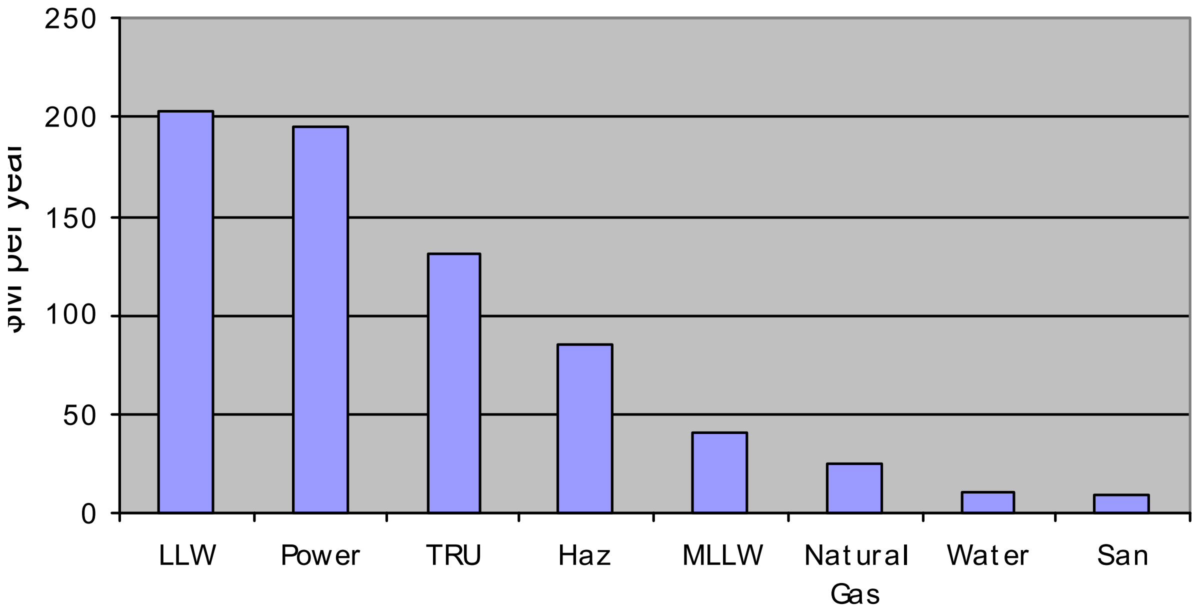


Fig. 1-2. Pareto analysis of outflows.

chemical vapors are released from research and production operations. Residual amounts of radioactive isotopes are released from the LANSCE air flow system. Depleted uranium and other materials are released to the ecosystem from unconfined explosive testing.

The Laboratory generates 3800 m^3 of radiological waste, mostly LLW. It generates 11,500 tons of hazardous waste, sanitary waste, and excess property, ~85% sanitary and excess. From FY97 through FY06, the EM Ten Year Plan estimates that radiological waste disposal will cost $306 million (exclusive of waste generator waste handling costs and ESH waste oversight costs). Over the same period, hazardous and sanitary waste will cost $87 million and the cost of purchasing electricity, natural gas, and water will cost $230 million. Over the next 10 years, these costs will total over $600 million. A significant fraction of this cost could be avoided.

Two other quasi outflows require discussion:

1. Local ecosystem impact. The presence of Laboratory facilities, infrastructure, operations, and land management affects local ecosystems. Much of this is unavoidable, and much of it is not necessarily harmful to the local environment. This local ecosystem impact can be minimized through wise operational choices. Examples of local ecosystem impact are fire management

practices, creation of artificial wetlands with effluent outfalls, unconfined explosive testing with depleted uranium, and wildlife management practices.

2. Regional environmental impact. The presence of the Laboratory in Northern New Mexico creates a need for roads, commuter transportation systems, and utility distribution systems. Laboratory support for initiatives (e.g., the Park and Ride Program) and distributing Laboratory operations to surrounding communities (e.g., the new JCNNM facility in Española) can minimize this regional impact.

1.3.5. Pareto Analysis of Outflows

The Stewardship Roadmap analyzes the Laboratory's materials flows by dividing the waste into waste types and analyzing the cost and environmental impact of each. A Pareto analysis bar chart of the outflows cost is shown in Fig. 1-2. LLW, which includes both solid LLW and liquid LLW sent to the RLWTF, has the greatest cost, followed by energy costs and TRU waste characterization and disposal costs. Note that the ER Project waste and TA-54 legacy waste have been excluded from the analysis summarized in Fig. 1-2. Waste costs are the Waste Management Program costs for storing, characterizing, treating, and disposing of waste. They do not include waste generator program costs for handling and managing waste, nor do they include ESH Division costs for overseeing waste or environmental activities.

The cost impact of the emissions, effluents, ecosystem impact, and regional environmental impact has not yet been analyzed; no conclusions can be drawn as to their relative cost importance.

In addition to costs, constraints and issues that may significantly impact life-cycle costs need to be considered. In rough order of importance, these are listed below.

- **Waste/Effluents.** Two major water/effluent issues are the following.

  1. With the transfer of the Laboratory water system to the County of Los Alamos, the Laboratory will have to keep water usage below 1600 acre-ft/year. With the evaporative cooling requirements of the new Strategic Computing Center added to present usage, this cannot be done without significant new conservation measures. The Landlord program (ALDNW) is investigating and plans to implement new conservation measures.

  2. Excess water now is released as effluent to the canyons (cooling tower blowdown and SWSC plant effluent). Most of these canyons are contaminated with radioisotopes. The effluent could be mobilizing this contamination, pushing it toward the Rio Grande. The extent to which

effluents, as compared with natural site drainage, contribute to contamination movement is not well understood. Effluent volume could be reduced through water efficiency improvements (specifically more efficient cooling towers) and recycling of gray water from the SWSC plant.

- **TRU Waste.** Three major issues related to TRU waste are the following.

    1. TRU waste is estimated to cost $70,000/m^3 to store, characterize, and prepare for shipment to WIPP. This does not include transportation-to-WIPP costs or WIPP disposal costs, which are separately funded by the DOE. TRU waste costs could be a significant drain on programmatic funds.

    2. TRU waste generated by programs not funded by the defense appropriation cannot be sent to WIPP. TRU waste from the Nuclear-Energy-Office-funded Milliwatt Heat Source Program (which produces small radiothermal generators that power deep-space probes) cannot be sent to WIPP. Currently, this waste is accumulating in TA-55 and TA-54, Area G. Correcting this will require amending the law that established WIPP.

    3. The WIPP waste acceptance criteria (WAC) limit the amount of radioactivity allowed in drums with hydrogenous materials (such as paper, wood, plastic, and cement). This limit is necessary to limit hydrogen gas generation during the trip to WIPP. For some radioisotopes (^{238}Pu and ^{241}Am), this limit is so restrictive that only a few items can be placed in each drum. There are many solutions for managing hydrogen buildup during transit to WIPP that do not require extreme limits on the amount of radioactivity in each drum. Development of these solutions must be accelerated; the WIPP WAC must be modified to authorize their use.

- **LLW.** Three major issues related to LLW are the following.

    1. The DOE directs its sites to operate under a no-radiation-added rule. This means that should Laboratory operations add a single atom of radioactive material to an item, that item must be disposed of as radioactive waste. This rule has been modified by DOE Order 5400.5, which sets release limits for nonporous, surface-contaminated items. The American National Standards Institute (ANSI) has drafted a standard (ANSI N13.12) for the free release of materials with small amounts of radioactivity added during operations. The DOE's adoption of this standard would eliminate the significant volume of very low or no-contamination radiological-control-area (RCA) waste now disposed of as LLW.

2. The Laboratory has 24,000 m^3 of disposal space remaining in the active part of Area G. If the Sitewide Environmental Impact Statement (SWEIS) is approved, the development part of Area G also could be used, ensuring at least another 100 years of LLW disposal capacity. If this element of the SWEIS is not approved, the Laboratory will have to ship LLW off site for disposal.

3. Laboratory unconfined-explosive-testing operations continue to release depleted uranium debris into the local ecosystem. The long-term environmental impact of this practice is not well understood.

- **Hazardous Waste.** Two major hazardous waste issues are the following.

  1. The Laboratory continues to receive a large number of fines for improper management of hazardous waste.

  2. The Laboratory generates many small quantities of "F"-listed RCRA wastes. Once a material is an F-listed waste, it always must be treated as such, even though the presence of the chemical that initiated the F-listing is no longer detectable. The EPA is considering relaxing the rules for F-listed wastes. Adoption of these rules would simplify the Laboratory's management of RCRA waste.

- **Emissions.** The Laboratory operates 10,000 tons of chillers using Class I ozone depleting substance (ODS) refrigerants (regulated by the Clean Air Act of 1990). Release of these substances from Laboratory operations contributes to the destruction of the earth's ozone layer. In many cases, replacing these chillers with non-ODS chillers can be financed from the improved energy efficiency of newer-technology chillers.

- **Power.** Laboratory electric power requirements will exceed contracted and available power capacity within 5 years.

- **Sanitary Waste.** The Los Alamos County Landfill, which disposes of the Laboratory's sanitary waste, has a 10-year life expectancy. Once it is filled, Laboratory waste will have to be shipped to another Northern New Mexico landfill, probably at significantly greater cost per ton.

Based on this analysis and available Stewardship Office resources, analysis priority was placed on water, TRU waste, LLW, MLLW, hazardous waste, and sanitary waste.

2.0. TRANSURANIC WASTE

2.1. Definition

TRU waste consists of materials contaminated with alpha-emitting radioactive elements with atomic numbers (Zs) greater than that of uranium (Z = 92) and with half-lives >20 years. Radionuclides meeting this definition and frequently encountered in LANL operations include ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Am, ^{237}Np, and ^{242}Cf. The contamination must be present at levels >100 nCi/g at the time of assay (DOE, 1988). Mixed transuranic (MTRU) waste is TRU waste determined to contain a hazardous component subject to RCRA in addition to its radiological component.

TRU waste at the Laboratory is classified as legacy waste and newly generated waste. Legacy waste is that waste generated through October 30, 1998; the DOE/EM is responsible for disposing of this waste at WIPP and for all associated costs. Newly generated waste consequently is defined as that waste generated after October 30, 1998; the DOE/Defense Programs (DP) is responsible for disposing of this waste at WIPP. This roadmapping effort will focus only on the newly generated wastes. Within this broad category, newly generated wastes are subdivided further into solid and liquid wastes, as well as routine and nonroutine wastes. Solid wastes include cemented residues, combustible materials, noncombustible materials, and nonactinide metals. Liquid wastes comprise effluent solutions associated with the nitric acid and hydrochloric acid plutonium-processing streams. Because of the final pH of these streams, they are also referred to and reported as the acid and caustic waste streams, respectively. Routine wastes are those associated with day-to-day operations, room trash, process residues, and spent chemicals and equipment. Nonroutine wastes are those resulting from process upsets, off-normal events (i.e., spills and accidents), and construction or process modification. TRU and MTRU wastes are reported separately because of the differing characterization requirements applied to wastes. These requirements are detailed in the RCRA and the Federal Facilities Compliance Order/Site Treatment Plan [the Federal Facility Compliance Order/Site Treatment Plan (FFCO/STP)—New Mexico Environment Department (NMED), 1995], which stipulates treatment requirements for MTRU wastes. If WIPP receives a No Mitigation Variance, these requirements will remain. However, the waste presumably will be shipped to WIPP without treatment, except as needed to meet storage requirements. In the following sections, TRU/MTRU wastes will be discussed as one water type because the waste minimization strategy for both waste types is the same.

2.2. Waste System Description

The majority of the TRU wastes generated at the Laboratory is associated with the Stockpile Stewardship and Management Program, the MilliWatt Heat Source Program, and nuclear materials research and development (R&D). NMT Division is the principal waste generator responsible for these programs, which are conducted at the Plutonium Facility (TA-55-PF4) and the CMR Facility (TA-3-SM-29). The MilliWatt Heat Source Program is the sole producer of ^{238}Pu-contaminated TRU waste. The remainder of the TRU waste is produced from waste characterization activities required for waste disposal at WIPP. These characterization activities are performed by Chemical Science and Technology (CST) Division. Figures 2-1 and 2-2 show TRU and MTRU waste generators by relative volume of waste generated.

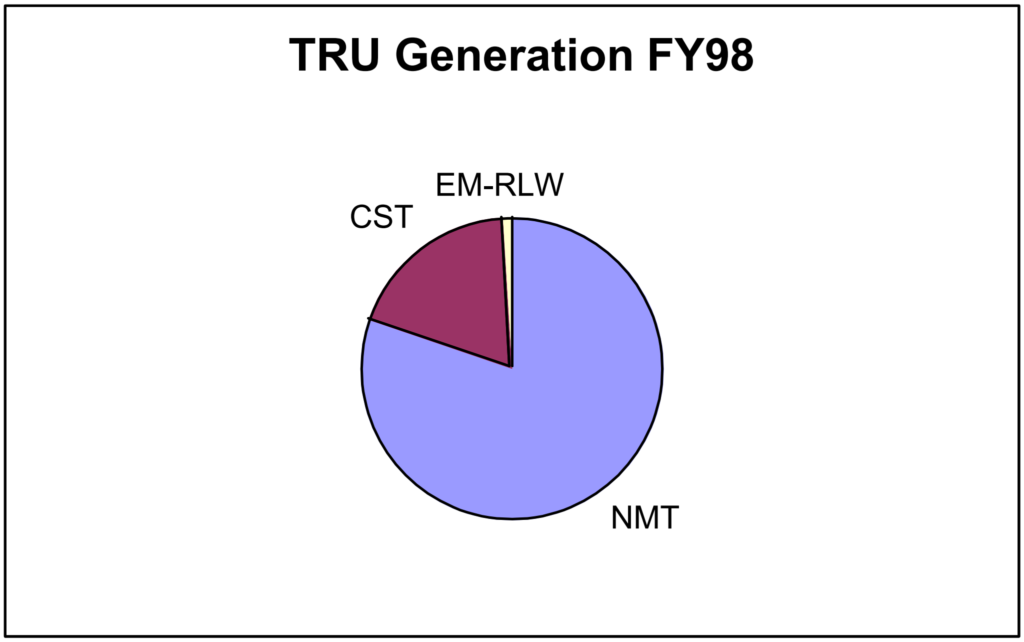


Fig. 2-1. TRU waste generation by Laboratory organization.

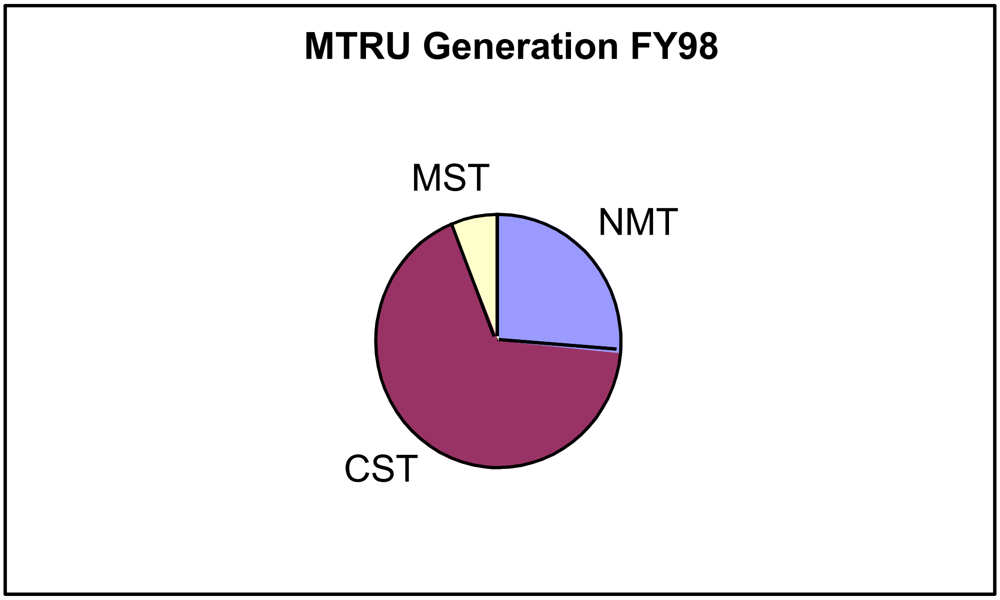


Fig. 2-2. MTRU waste generation by Laboratory organization. MTRU waste generation is less than 10% of TRU waste generation.

The ER/Decontamination and Decommissioning (D&D) Program has produced TRU waste intermittently; this production is related directly to the area or facility being remediated or decommissioned. In FY97, significant quantities were generated because of the D&D of TA-21, which was the old uranium and plutonium processing site. In FY98, no TRU waste was generated.

TRU wastes are generated within RCAs. These areas are also material balance areas (MBAs) for Security and Safeguards purposes to prevent the potential diversion of special nuclear material (SNM). The top-level process map for TRU waste is shown in Fig. 2-3.

TRU (SNM) materials, process chemicals, equipment, supplies, and some RCRA materials are introduced into the RCAs in support of the programmatic mission. All SNM introduced into Building PF-4, TA-55, except for those quantities currently being processed, are stored in the vault in the PF-4 basement until needed. Because of the hazard inherent in the handling, processing, and manufacturing of plutonium materials, all process activities involving plutonium are conducted in gloveboxes where the plutonium can be isolated from the worker and the facility environment. Extremely high levels of plutonium contamination can build up on the inside surfaces of gloveboxes and process equipment because of the process or leaking process equipment. All materials being removed from the gloveboxes for storage in the vault, transfer to downstream processes, or disposition as wastes must be multiple-packaged to prevent the uncontrolled spread of contamination outside the glovebox. Currently, all material removed from gloveboxes or part of the processing equipment is considered to be TRU waste. Large quantities of waste, primarily solid combustible materials such as plastic bags, cheesecloth, and protective clothing, are generated to isolate plutonium from the worker, facility, public, and environment.

Nonactinide metals are another major TRU waste stream and consist of end-of-lifetime gloveboxes, storage tanks, processing equipment, piping, tools, and transfer containers. The process residues with residual plutonium contamination less than the Safeguards Termination Limits (STLs) and cemented evaporator bottoms are other TRU waste solids generated during process operations. Process residues exceeding the STL values are returned to the vault for storage and future reprocessing. The pie charts in Fig. 2-3 depict the percentage each waste type contributes to the total TRU waste volume generated. In FY98, 102 m^3 of solid TRU waste was generated. Of this, 27% was combustible material, 22% was noncombustible, 32% was nonactinide metals, and ~18% was cemented process sludge and residues.

TRU solid wastes are accumulated and initially assayed and characterized at the generation site. TRU solid waste is packaged for disposal in metal 55-gal. drums, 4-x-4-x-6-ft standard waste boxes (SWBs), and oversized containers. Security and Safeguards assay measurements are conducted on the containers before they are removed from

PF-4 for SNM accountability purposes and to ensure that no significant quantity of SNM has been diverted. The 55-gal. drums are stored in an auxiliary building at TA-55. The SWBs and oversized containers are staged on an asphalt pad behind PF-4 awaiting

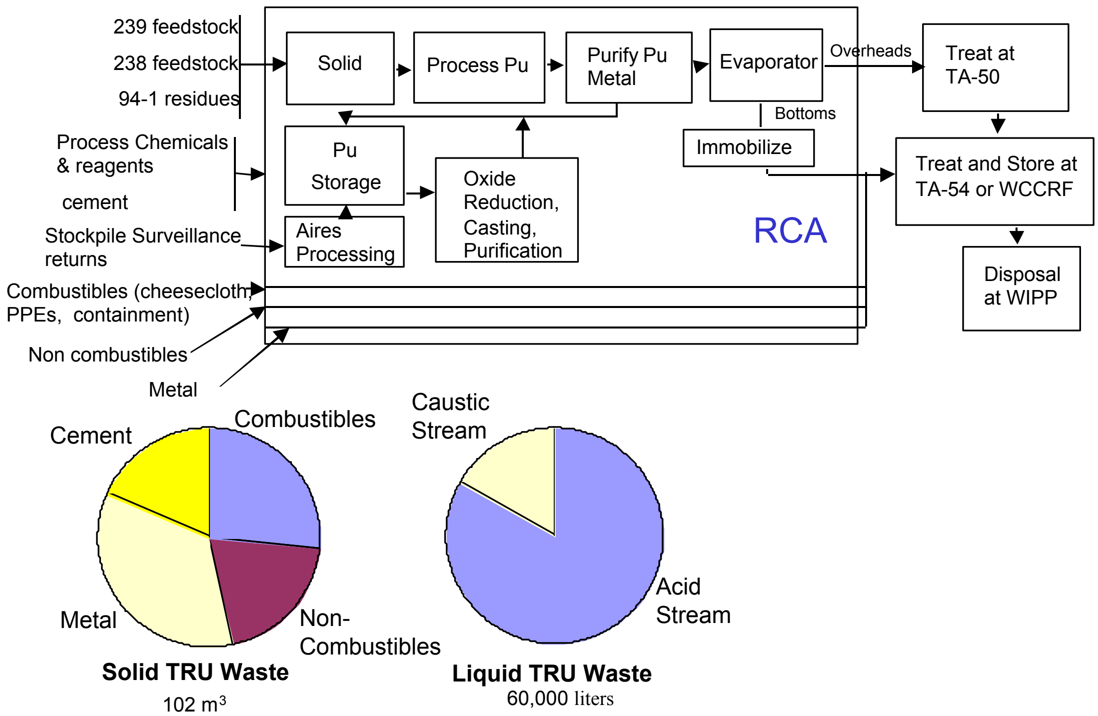


Fig. 2-3. Top-level TRU waste process map and waste streams.

shipment to TA-54 for interim storage. Before being shipped to WIPP, the TRU waste containers will be transported to the TRU waste characterization areas at TA-54 or TA-50. Detailed characterization of TRU wastes occurs at Building 54-34, the Radioassay And Nondestructive Testing (RANT) facility; and at Building 50-69, the Waste Compaction, Reduction, and Repackaging Facility (WCRRF). Samples for characterization from drums in some cases are sent to the CMR building for analysis. TRU/MTRU waste is stored at TA-54, Area G until it is shipped to WIPP for final disposal. Certification of the waste for transport and disposal at WIPP is the responsibility of the Environmental Science and Waste Technology Group (CST-7). Waste shipments to WIPP are anticipated to begin in January 1999.

Liquid TRU wastes from the nitric acid (acidic) and hydrochloric acid (caustic) aqueous processes are transferred from TA-55 to the TA-50 RLWTF via separate, doubly encased transfer lines for processing and further removal of plutonium by flocculent precipitation. The precipitate is cemented into 55-gal. drums and transported to TA-54 for storage and ultimate disposal at WIPP as TRU solid waste. In FY98, ~60,000 L of liquid TRU waste was processed at the TA-50 RLWTF. Eighty percent of this volume came from the acid waste stream and the remaining 20% from the caustic waste stream.

Costs for handling, storage, and disposal of TRU/MTRU waste have been estimated at approximately \$50,000/m^3, based on average costs per unit volume from the available draft of the DOE/EM Ten Year Plan. In FY99, these costs are expected to rise to an average of \$76,500/m^3 because of increased costs of characterization, storage, and disposal.

2.3. Issues and Constraints

2.3.1. Waste without a Disposal Pathway

Recent DOE/DP guidance prohibits (without approval) the continued generation of TRU waste that does not have a disposal pathway. The Land Disposal Act governing the types and characteristics of TRU waste destined for disposal at WIPP prohibits the disposal of non-DP TRU waste. Plutonium-238-contaminated wastes generated in association with the National Aeronautics and Space Administration (NASA) Heat Source Program are non-DP wastes and thus cannot be disposed of at WIPP under current regulatory restriction. Consequently, all ^{238}Pu wastes must be stored on site awaiting a disposal option. The DOE/Albuquerque Operations Office (AL) has established a procedure for obtaining approval to produce a waste that does not otherwise have a disposition pathway.

2.3.2. Thermal Wattage Limit for WIPP Transportation

Current Nuclear Regulatory Commission (NRC) regulations concerning the transportation of TRU wastes to WIPP limit the ^{239}Pu equivalent loading to 0.2 g per drum to ensure that the hydrogen generated in the headspace does not exceed explosive values. The assumptions utilized in the calculations to derive these headspace values are conservative and pose significant challenges. Although several efforts are underway to adopt revised values, TRU wastes from several of the waste streams will require significant dilution to increase the current thermal wattage limits. For some ^{238}Pu wastes, this dilution can result in a tenfold increase in waste volumes. Cemented wastes, from the immobilization of process sludge produced from treatment of the acidic and caustic waste streams, may require a threefold increase in waste volumes to meet the wattage limits. WIPP is preparing an amendment to the existing G-values used in the headspace generation calculations, which could relax the thermal limits by a factor of two to three. This requested change is expected to be submitted for consideration by the NRC in FY99.

2.3.3. Centralized Decontamination and Volume-Reduction Capability

Decontamination of TRU wastes comprised of large metallic objects for disposal as LLW is performed primarily in place using electrolytic decontamination, chemical washing, or some other technique. Frequently these items, including gloveboxes, are recontaminated before they can be removed from the facility because of ventilation upsets. A centralized decontamination and volume-reduction facility is needed to allow these large items to be removed from the facility, relocated, decontaminated, and volume-reduced to minimize the cost of disposal. For many TRU waste gloveboxes, this will require removing lead shielding so that the gloveboxes can be disposed of as LLW rather than MLLW, which has no disposal pathway. Because of the safety concerns posed when performing operations with high levels of TRU waste contamination, the construction of this type of facility is both time consuming and expensive. The Decontamination and Volume Reduction System (DVRS) being designed and built at TA-54 will meet this need for gloveboxes. However, the present DVRS design does not allow for decontamination and volume reduction of storage tanks, long process piping, and process equipment. In addition, an alternate facility for glovebox decontamination and volume reduction is needed until the DVRS is fully operational, which currently is expected to occur in July 1999 at the earliest. Therefore, to ensure that such a capability to treat TRU-waste oversized metallic objects effectively is available to meet the needs of the Laboratory, a plan must be developed and implemented as soon as possible.

The role of DRVS must be acknowledged in this constraint.

2.3.4. NDA Differentiation between TRU Waste and LLW

Existing nondestructive assay (NDA) measurement techniques are significantly challenged and frequently fail to differentiate TRU waste from LLW when the levels of activity fall between 10 and 100 nCi/g. This limitation is particularly pronounced when the background radiation levels are elevated, as they are at some locations in the TA-55, PF-4 facility. Consequently, significant quantities of LLW are improperly classified as TRU waste and must be handled at a much higher cost. Improper classification of waste at the time of generation will be discovered later when the waste is prepared for disposal at WIPP. This issue can be critical for MTRU waste, which may have no disposal pathway if it were reclassified as MLLW.

2.3.5. WIPP Characterization Requirements

Characterization requirements for TRU/MTRU wastes that are destined for burial at WIPP are intensive, time consuming, and expensive. State regulatory jurisdiction over MTRU waste is causing an additional burden on the waste generators as questions concerning knowledge of process and adequacy of segregation between waste streams continue to delay the initial shipment of TRU waste to WIPP. LANL has developed a detailed sampling plan to demonstrate that the contents of the TRU waste drums scheduled for the first shipment are characterized adequately and do not contain any RCRA constituents. RCRA contaminants currently are prohibited from shipment until the State of New Mexico issues the RCRA, Part B permit authorizing disposal of RCRA wastes, and thus, MTRU wastes at WIPP.

2.3.6. Decontamination of MTRU Waste to MLLW

Significant manpower and funding resources are being expended to minimize the quantity of TRU and MTRU waste being generated. Decontamination of gloveboxes from TRU waste to LLW is included in the focus of this effort. However, many gloveboxes and other process equipment contain or have been contaminated with RCRA-regulated constituents such as lead. Currently, there is a disincentive for decontaminating MTRU wastes to LLW levels without eliminating the RCRA constituents because there is frequently no disposal pathway for MLLW. Decontamination strategies must account for this potential to ensure that the final waste has a disposal pathway.

2.3.7. Construction

The Laboratory will spend over $1.2 billion over the next 10 years upgrading facilities and process equipment to meet the changing mission that is focused on the Stockpile Stewardship and Management Program. Much of the activity will be in RCAs and will involve the replacement of TRU-waste-contaminated systems and equipment. Large quantities of TRU and MTRU wastes requiring high costs for disposal will be generated unless pollution prevention and waste minimization are included and fully integrated into the overall construction process.

2.4. Waste Streams

As discussed in detail in Section 2.2.3, the TRU waste stream is the result of Laboratory missions focused on the Stockpile Stewardship and Management Program, MilliWatt Heat Source Program, and nuclear materials R&D. NMT is the predominant generator of TRU/MTRU wastes. In their efforts to reduce the types and quantities of plutonium-contaminated wastes being generated and to minimize the total quantity of plutonium being discarded annually, NMT has committed to a path forward that is described in detail in the TA-55 Waste Minimization Program Plan (Foxx, 1996). This plan provides in-depth discussion of the projects and goals of the Division. Additionally, NMT recently has developed and issued the NMT Waste Management Program Plan that presents the philosophy and expectations for environmentally conscious plutonium processing with goals to reduce liquid waste by 90% and to essentially eliminate the combustible waste stream by 2003.

As with the other sections, the waste-stream analyses are organized into (1) a waste-stream description including a summary of recent waste minimization successes; (2) waste-stream reduction options; and (3) waste-stream performance measures, objectives, and schedules. (Note: waste-stream performance objectives and schedules are not included in this version of the roadmap.) The waste-stream reduction options include procedural changes requiring no funding, funded projects, well-defined but unfunded projects, and waste-reduction concepts that require further definition.

2.4.1. Combustible Wastes

Combustible wastes comprise ~27% of the solid TRU waste generated at the Laboratory. For the MilliWatt Heat Source Program, combustible solids account for almost 90% of the TRU wastes contaminated with ^{238}Pu, for which there is currently no disposal pathway. In all instances, combustible waste is comprised largely of plastic bags, plastic reagent bottles, plastic-sheet goods used for contamination barriers, organic chemicals and oils, cheesecloth, gloves, and protective clothing worn by workers for protection from plutonium contamination. The process map and identified options are shown in Fig. 2-4. When combined, these options are expected to eliminate or significantly reduce this waste stream. MTRU combustible waste is generated largely from the frequent changing and disposal of leaded gloves used in gloveboxes to isolate workers from the highly contaminated internal surfaces and operations inside. Damage to the gloves from heat, chemicals, alpha contamination, mechanical abrasion, and punctures mandate routine replacement of the gloves to prevent the potential airborne releases of plutonium. Glove failures are the single most prevalent cause of airborne releases or spills of plutonium into the work and facility environment. Spills generate large quantities of LLW from cleanup operations and are discussed in greater detail in the LLW section of the roadmap.

As depicted in Fig. 2-4, NMT Division has taken numerous and aggressive actions to minimize and eliminate the combustible waste stream. These actions are detailed in the TRU Combustibles Matrix Destruction/Treatment Approach. This plan details NMT's vision for trial implementation, evaluation testing, and downsizing selection of treatment options to address the various combustible waste streams associated with plutonium operations. The various treatment options are discussed in detail below. In

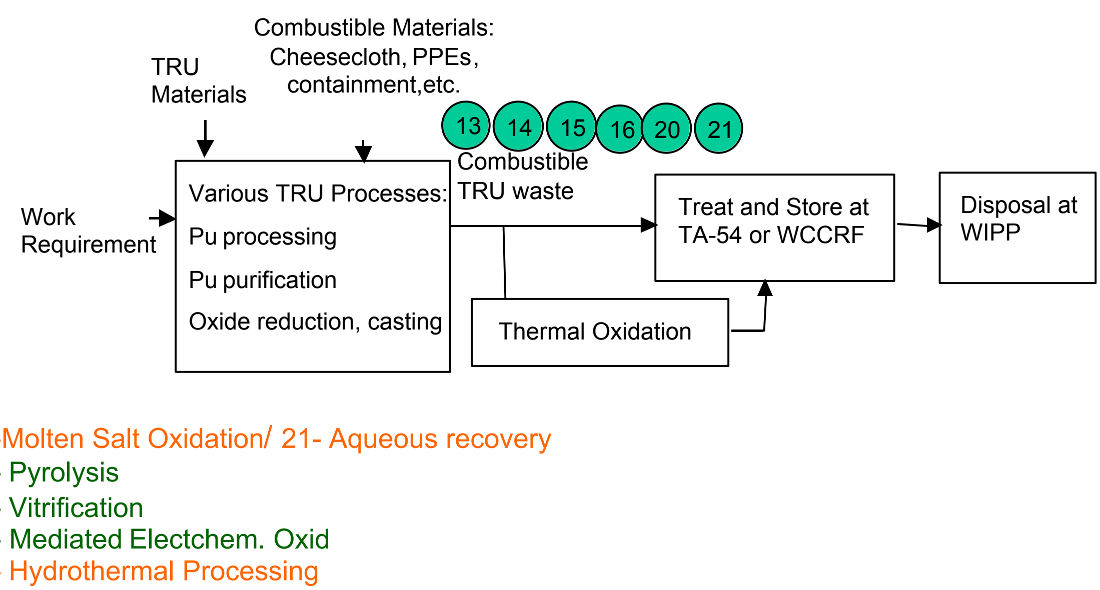


Fig. 2-4. Process map for combustible TRU waste.

addition to this plan, several other programs have been implemented to reduce the quantities and types of combustible wastes being generated, including

1. extensive training for all PF-4 workers, which focused on the need for and ways to prevent and minimize waste as part of the access control program;

2. incorporation of waste minimization practices into routine facility procedures;

3. significant expansion of the NMT-7 Waste Management and Environmental Compliance Group to assist operation personnel with waste management issues, including a Project Leader for Waste Minimization to lead the efforts on combustible waste treatment technologies selection and downsizing; and

4. prohibition on bringing unnecessary items into PF-4 that must be removed as waste and the development of an alternative technology to treat combustible cheesecloth when the incineration process was suspended because of State and political opposition.

2.4.1.1. Improvement Options

2.4.1.1.1. Option TRUComb.1. Pyrolysis and Catalytic Conversion. This process destroys organic matrices (e.g., cellulose rags, plastics, and gloves) by thermal decomposition. Byproducts include liquid and vapor phase organic compounds. A 150-g/day throughput unit has been installed in TA-55 and used to decompose polystyrene and cellulose rags. A large-scale pilot unit able to decompose 500 g/day is being developed for installation. Efforts also are proceeding to develop and test a unit capable of destroying other plastics. Waste-avoidance type: treatment. (Source, NMT-2, NMT-6, NMT-7)

2.4.1.1.2. Option TRUComb.2. Hydrothermal Destruction. With hydrogen peroxide as the oxidant, organic wastes are oxidized to carbon dioxide and water at high temperature and pressure. This process is suitable for treating organic liquids and small-particle-sized solids. The products are a slightly acidic solution and precipitated actinide compounds. Currently, an experimental unit is operational in a TA-55 glovebox. A larger pilot-scale system needs to be designed and tested on a wider variety of combustible waste materials. A cost of $3.8 million over 2 years is needed to implement this technology for treatment of TRU waste combustibles at TA-55, including MTRU wastes, plastics, paper, and rubber gloves. Waste-avoidance type: treatment (and requires an RCRA treatment permit if influent includes RCRA wastes). (Source, NMT-6, NMT-7)

2.4.1.1.3. Option TRUComb.3. Mediated Electrochemical Oxidation. This process for the destructive oxidation of hazardous organic compounds in waste solutions is being installed at the CMR building to treat both newly generated and legacy mixed waste. The destructive oxidation utilizes a metallic ion in an electrochemical solution, such as silver (II), cobalt (III), or cerium (IV), and produces carbon dioxide, inorganic acids, and water. This destruction technology eliminates the hazardous component in the waste, provides an alternative to incineration (with its difficult permitting issues), and avoids the increased liquid volumes generally associated with other types of chemical oxidation. This process also has been demonstrated to dissolve plutonium oxide. This process would require approximately $1 million over a 1.5-year period to deploy in a glovebox at TA-55. Waste-avoidance type: plutonium recycle (although this requires an RCRA permit if influent includes RCRA wastes). (Source, NMT-6, NMT-7)

2.4.1.1.4. Option TRUComb.4. Molten Salt Oxidation. Combustible organic materials are decomposed of by combining them with oxygen in a molten carbonate bath. This process works on organic wastes and pyrolysis ash. The byproducts are carbon dioxide, water, and contaminated carbonate salts. This process currently is being pursued by NMT-9 to treat ^{238}Pu-contaminated combustible materials and has received DOE EM-50 ASTD funding to develop and deploy the technology within a glovebox environment at TA-55. When combined with aqueous recovery of the plutonium present in the carbonate salts, the ^{238}Pu constituent can be recovered and purified for reuse. The technology has been demonstrated for the destruction of rocket propellant, military ordinance, and plutonium recovery. The implementation cost for this technology is about $3.5 million over 2 years. Waste-avoidance type: plutonium recycle. (Source, NMT-9, NMT-7)

2.4.1.1.5. Option TRUComb.5. Volume Reduction Using Cryogenic Grinding. This process subjects plastic materials to extremely cold temperatures using liquid nitrogen and then grinds the frozen material in a mechanical grinder. The process reduces the waste volume by ~70%. Cryogenic grinding has been demonstrated, and a large-scale design is needed. This technology can be implemented at TA-55 for $500,000 in 1 year. Implementation of this technology will provide the size-reduction capabilities necessary to feed these materials into the equipment discussed previously. Waste-avoidance type: volume reduction. (Source, NMT-6, NMT-9)

2.4.1.1.6. Option TRUComb.6. Elimination of PVC Plastics. Many of the plastic gloves, bottles, bags, and contamination barriers currently in use within PF-4 are made from polyvinyl chloride (PVC). When PVC is decomposed thermally, one of the byproducts is hydrochloric acid, which is quite corrosive and rapidly destroys metallic process equipment, gloveboxes, facility piping, and ventilation ducting. Substitution of an alternative plastic such as polyethylene will eliminate the generation of acids and will significantly prolong process equipment lifetimes. Waste-avoidance type: material substitution. [Source, NMT-7, EM-Environmental Stewardship Office (ESO)]

2.4.1.1.7. Option TRUComb.7. Use of Polyvinyl Alcohol-Based Materials. Cloth-like fabrics, mopheads, clear sheet goods, and other substitutes for cellulose-based products now are being manufactured and used extensively in the medical industry. The new generation of polyvinyl alcohol (PVA) materials remains soluble in aqueous solutions and now can withstand water bath temperatures up to 190°F. If alternate treatment technologies could be employed to dissolve, treat, and recover the plutonium from this material, these products could provide an alternative to the cellulosic products requiring thermal decomposition technologies to treat and destroy. Waste-avoidance type: material substitution. (Source, NMT-6, EM-ESO)

2.4.1.1.8. Option TRUComb.8. In-Line Waste Assay and Packaging System. Waste generated in gloveboxes at PF-4 is removed from the glovebox line via the bag-out process to be assayed. The plastic-bagged item is placed into a drum that is lined with a heavy PVC bag. The bags of waste items capture air along with the waste item and typically are packaged in an irregular manner in the drum. Multiple void spaces result from this method of packaging. Efforts to reduce the void spaces by personnel compressing the waste items or even puncturing the individual bags has resulted in airborne plutonium releases into the room.

Waste streams from PF-4 gloveboxes could be assayed, sorted, and segregated more effectively and safely as TRU and LLW wastes if this activity were performed in-line. In addition, a significant volume of PVC waste could be avoided and more material packaged into a single drum if the drum-out were conducted in-line. It is expected that implementation of this option would decrease the volume of drums generated in PF-4 by 50%.

LANL is working cooperatively with Idaho National Energy and Environmental Laboratory (INEEL) to design and develop this capability within PF-4. The cost of reconfiguring equipment and facilities in Rooms 431 and 432 of PF-4 and installation of the new system is estimated at $3 million. Waste-avoidance type: source avoidance, segregation, and volume reduction. (Source, NMT-7)

Performance Measures

1. Volume of cellulose materials used within PF-4.
2. Volume of combustible materials destroyed using thermal decomposition.
3. Volume of combustible materials discarded without treatment.

2.4.2. Noncombustible TRU Waste

Noncombustible TRU wastes are composed of materials that prohibit thermal decomposition treatment because mixed metallic, glass, graphite, or other noncombustible materials exceed 10% of the waste volume. The process map for noncombustible wastes is shown in Fig. 2-5.

NMT has reduced the volume of noncombustible TRU wastes through improved segregation at the time the waste is generated. Although discussed in greater detail later, diversion of glass waste to the vitrification process and introduction of reusable tantalum molds for component casting also will contribute significantly to the reduction of noncombustible waste volumes.

2.4.2.1. Improvement Options

2.4.2.1.1. Option TRUNComb.1. Aliquot Mold and Blending. Casting plutonium metal with varying isotopic ratios into small ingots that can be blended to produce a material casting with more uniform characteristics allows for blending out-of-specification materials to yield materials with isotopic ratios that are within specification. Once an acceptable mold for ingot casting is developed and hot tested using plutonium metal, reusable tantalum molds will be fabricated to replace the graphite molds. The tantalum molds are expected to withstand up to several hundred castings per mold over several years, whereas the graphite molds typically only survive 5 to 10 castings before they must be discarded and replaced. Implementation of this option will eliminate the disposal of graphite molds and reduce the amount of material requiring reprocessing. Eliminating the need to reprocess material also will eliminate the waste currently generated from this activity. Waste-avoidance type: source reduction. (Source, NMT-5)

2.4.2.1.2. Option TRUNComb.2. Laser-Induced Breakdown Spectroscopy. Plasma ionization of microgram samples of plutonium using a laser produces characteristic photon patterns that can be evaluated to determine the isotopic content and ratios

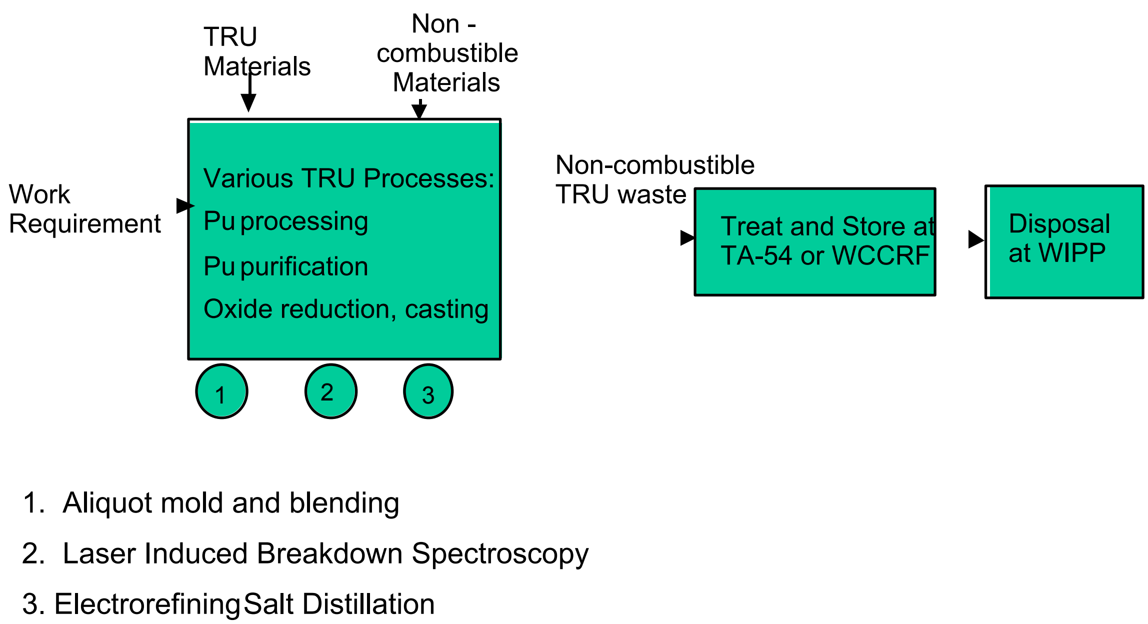


Fig. 2-5. Process map for noncombustible TRU waste.

present in the sample. Unwanted contaminants also can be quantitatively and qualitatively measured with an analytical turnaround time of hours rather than the months necessary using current analytical chemistry techniques. Eliminating the need for the multigram sample sizes currently required will prevent the need to dispose of the remaining sample or to return it for reprocessing. Adoption of this new analytical technique will virtually eliminate the waste currently associated with this activity. Waste-avoidance type: source reduction. (Source, NMT-6)

2.4.2.1.3. Option TRUNComb.3. Electrorefining Salt Distillation. This process distills the potassium and sodium nitrate salts used in several pyrochemical processes away from the solid nuclear material oxides. It produces salts that are reusable and no longer must be discarded as LLW or TRU waste. Waste-avoidance type: internal recycle. (Source, NMT-2, NMT-7)

Performance Measures

1. Volume of noncombustible waste avoided by incorporating glass discards into the vitrification process.

2. Volume of graphite molds saved from discard by application of tantalum molds.

3. Volume of noncombustible waste generated vs previous years.

2.4.3. Nonactinide Metals

Nonactinide metals are any metallic waste constituents that may be contaminated with, but are not fabricated out of, actinide metals. Metallic wastes typically comprise tools, process equipment, glovebox structure or facility piping, and ventilation ducting. MTRU waste issues associated with this waste stream are described in greater detail in the corresponding section under mixed waste. Figure 2-6 presents the process map and lists the improvement options for metallic TRU waste. It is estimated that implementation of these options could reduce this waste stream by 90%. Significant volumes of metallic waste are generated under the following conditions: (1) when gloveboxes have reached the end of their useful lifetimes; (2) when processes within the facility and glovebox need change; (3) when routine and nonroutine maintenance activities are completed; and (4) as facility construction projects are implemented to meet new programmatic missions, such as the CMR and TA-55 upgrade projects.

2.4.3.1. Improvement Options

2.4.3.1.1. Option TRU.Met.1. Electrolytic Decontamination. The electrolytic decontamination of gloveboxes and other metallic components can reduce them from TRU waste to LLW or make them more attractive for reuse because of the lower levels of residual contamination. Use of electrolytic decontamination sharply reduces the volume of solid and liquid waste generated by other decontamination techniques. Because the process is more rapid then other techniques and because the technique can be left unattended for periods of time, workers receive a lower radiation dose during the course of decontamination using this technique. Waste-avoidance type: external reuse or treatment. (Source, NMT-6, CST-7)

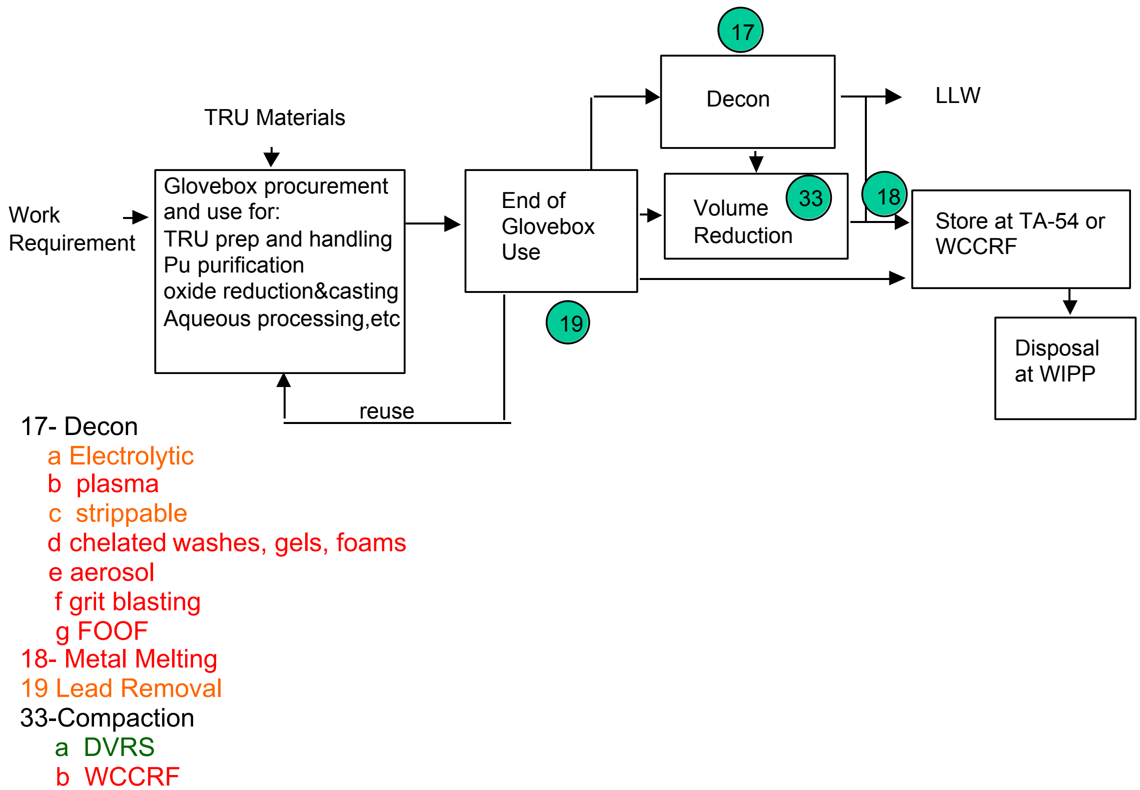


Fig. 2-6. Process map for nonactenide metallic waste.

2.4.3.1.2. Option TRU.Met.2. Use of Chemical Decontamination Agents. Numerous variations on new chemicals for decontamination of equipment and surfaces are being developed. Some of these include leaching gels and foams that are supposed to be effective for decontaminating nonmetallic surfaces, such as those in many of the gloveboxes scheduled for removal from CMR. Testing and evaluation of these products to identify the most effective decontamination agent could reduce the volume of TRU waste generated from CMR significantly. Waste-avoidance type: external reuse or treatment. (Source, NMT-1, CST-7)

2.4.3.1.3. Option TRU.Met.3. Precious Metal Decontamination. Approximately 100 kg of plutonium-contaminated precious metals has been identified as a candidate for electrolytic decontamination as part of the 94-1 vault cleanout and residue stabilization program. The estimated value of the gold, platinum, and platinum/rhodium alloys is approximately $1 million. After decontamination, a significant portion of this precious metal will be returned to the DOE Precious Metal Pool for reuse throughout the complex. Implementation of this project will result in ~4 to 5 m^3 of TRU waste avoidance. Waste-avoidance type: external recycle. (Source, NMT-2, CST-7)

2.4.3.1.4. Option TRU.Met.4. Use of Strippable Coatings. The use of strippable coatings could be increased to minimize the need for extensive glovebox decontamination activities before glovebox reuse or removal. Use of these coatings could decrease the amount of TRU waste generated by increasing the number of gloveboxes decontaminated to LLW levels or free-release criteria. Gloveboxes decontaminated to these levels then could be reused or recycled. Waste-avoidance type: external recycle or treatment. (Source, NMT-7)

2.4.3.1.5. Option TRU.Met.5. Glovebox Design for Future Activities. LANL is working cooperatively with INEEL to design and develop the next generation of gloveboxes to meet future programmatic requirements. The new design will implement many design features to ease decontamination activities and eliminate the MTRU waste issues caused by the use of lead shielding. As this design nears completion, more information will be provided. Waste-avoidance type: source avoidance. (Source, NMT-7)

2.4.3.1.6. Option TRU.Met.6. Centralized Decontamination and Volume Reduction Activities at WCRRF, TA-50. With the increasing costs to generate and dispose of TRU metallic wastes, a centralized facility located outside of TA-55 and the CMR Facility is needed to perform more adequate decontamination of materials from TRU waste to LLW, remove lead if present, eliminate the mixed waste component of the stream, more accurately assay residual contamination, and volume reduce the oversized components. This capability is needed to effectively treat oversized metallic objects that cannot be handled by the DVRS and to provide an interim capability for gloveboxes until the DVRS becomes operational in July 1999. A proposed project plan will be developed to outline this activity further.

2.4.3.1.7. Option TRU.Met.7. Construction and Operation of the DVRS at TA-54. The DVRS currently is being designed for installation and deployment at TA-54 to handle oversized metallic legacy and newly generated TRU glovebox wastes. This facility has received DOE EM-50 ASTD funding and is scheduled for completion in July 1999. However, as currently configured the DVRS cannot handle large storage tanks, process piping, or process equipment without some level of previous size reduction or decontamination of internal pipe surfaces.

2.4.4. Cement Waste

Cemented wastes are those acidic and caustic processing sludges and oxalate precipitation residues that contain residual levels of plutonium contamination that exceed the STLs but are less than the values requiring reprocessing. Before being discarded, the residues must be immobilized to minimize their potential attractiveness for diversion. Cementation meets this immobilization requirement. These high concentrations of actinide radioactivity frequently exceed the thermal wattage limit for WIPP disposal and would require dilution by as much as a factor of five to meet certification requirements. NMT has been pursuing several alternatives to resolve this issue. The process map for cement waste is shown in Fig. 2-7.

2.4.4.1. Improvement Options

2.4.4.1.1. Option TRUCem.1. Vitrification. Vitrification of radioactive wastes is the high-temperature process of converting solid and semisolid waste streams into monoliths using glass frits as a medium for stabilization. Vitrification of these wastes is a desirable solution to the current problems of hydrogen generation and container corrosion associated with cemented wastes. Because hydrogen generation will no longer be of concern in the vitrified waste form, the loading of TRU wastes into

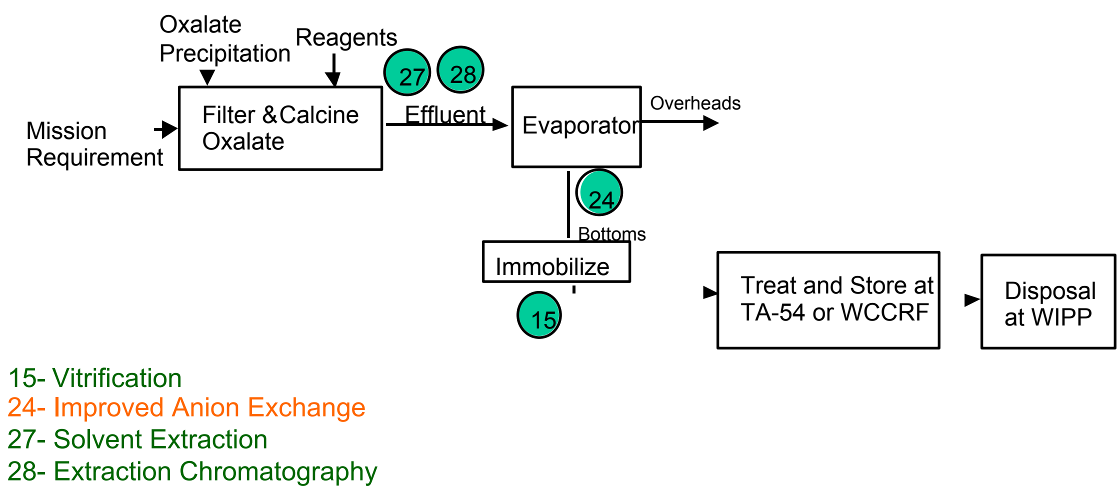


Fig. 2-7. Process map for cemented TRU waste.

this waste form can be increased substantially over the loading currently acceptable in the cemented waste form. The increase in TRU waste loading will dramatically reduce the volume of waste currently produced. The process is currently under development at pilot scale at TA-55. LANL is working cooperatively with INEEL to design and install the vitrification system within PF-4. More detailed descriptions of this program will be developed as the design is finalized and readied for installation. Waste-avoidance type: treatment. (Source, NMT-2)

2.4.4.1.2. Option TRUCem.2. Improved Ion Exchange Resins. New ion exchange resins are being developed and synthesized with improved absorption characteristics for plutonium and americium. These resins are intended to replace existing resins in the nitric acid processing stream. Use of these resins will increase the amount of plutonium and americium recycled and will significantly reduce the concentrations of these actinides in the cementation waste stream. Reducing the actinide concentrations will increase the quantity of evaporator bottoms that can be added to each drum and yet still meet thermal wattage limits for WIPP certification, reducing the total volume of cemented waste produced. Pilot-scale column testing and radiolytic stability testing of the new resins still is required. Direct replacement of existing resins with the new resins will cost $750,000 over 2 years and will be accomplished as the current resin beds load and require disposal. Waste-avoidance type: internal recycle. (Source, NMT-6, NMT-7)

2.4.4.1.3. Option TRUCem.3. Electrochemical Ion Exchange. After chemical species are loaded onto typical ion exchange resin systems, they usually are eluted with strong acids or bases. The use of these eluents increases the amount of total dissolved solids in the aqueous waste stream requiring treatment. Electrochemical ion exchange utilizing an electric current to generate the hydrogen ion concentrations required for elution eliminates the need for acid eluents. Implementation of this system will reduce the total dissolved solids present in the aqueous waste streams dramatically. Although this has been applied commercially, it is just now being evaluated for application at LANL. More detail will be provided at a later date. Waste-avoidance type: internal recycle. (Source, NMT-6, NMT-7)

Performance Measures

1. Volume of vitrified TRU waste generated.
2. Volume of cemented TRU waste generated.
3. Number of WIPP certifiable drums generated.
4. Number of noncertifiable drums generated.

2.4.5. Caustic Liquid Waste

Caustic liquid waste results from the final hydroxide precipitation step in the aqueous chloride process. Feedstocks for this process are typically anode heels, chloride salt residues, and other materials having a relatively high chloride content. Figure 2-8 provides the process map for this waste stream. Current efforts are underway to upgrade the throughput capabilities of the aqueous chloride process to handle the increased quantities of chloride residues that will require work-off under the 94-1 Residue Stabilization Program. Over the next 3 to 5 years, throughput quantities are expected to double. Process caustic liquids are transferred to TA-50, RLWTF, for final processing via the caustic waste line. Further detail on TA-50 processing will be added at a later date.

2.4.5.1. Improvement Options

2.4.5.1.1. Option TRUCaus.1. Scintillating In-Line Alpha Counter. The scintillating in-line alpha counter is a real-time process monitor developed for measurement of process solution concentrations. This allows operators to make rapid decisions concerning the desirability of recycling process solutions to reduce effluent concentrations further. This real-time decision-making capability can reduce the quantity of hydroxide cake that exceeds the STLs and would require immobilization or reprocessing. By installing multiple monitors at various points in the process stream,

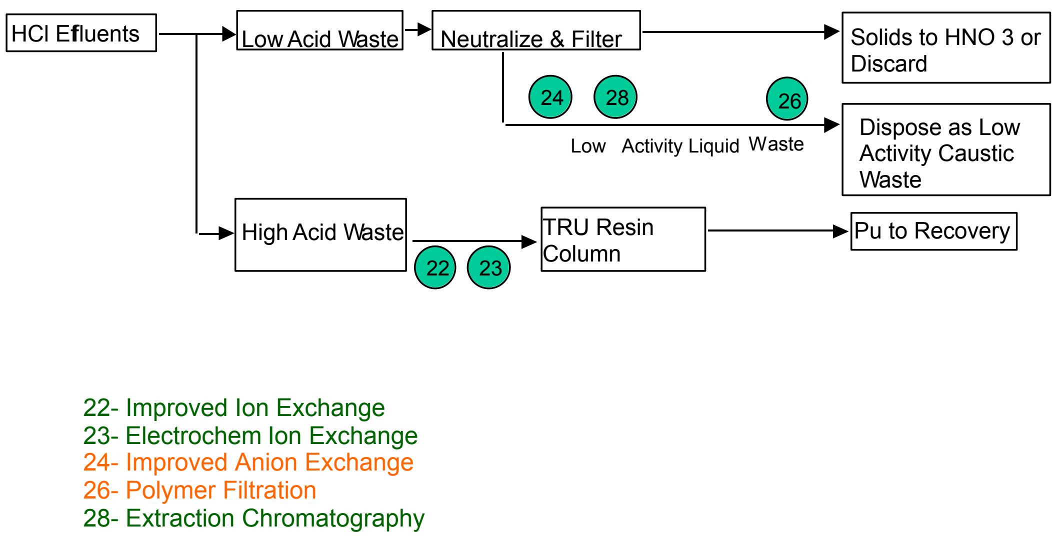


Fig. 2-8. Process map for caustic liquid TRU waste.

plutonium recovery rates can be optimized. Optimization of the plutonium recovery rates reduces the amount of plutonium that must be discharged to the RLWTF. Reducing these discharges will decrease the amount of TRU waste generated at the RLWTF. This technology already has been developed using 94-1 Residue Stabilization funding and is being implemented by NMT-2 and CST-13 on the aqueous chloride process. Waste-avoidance type: source reduction. (Source, NMT-2)

2.4.5.1.2. Option TRUCaus.2. Waste-Stream Polishing. A solution containing small quantities of dissolved actinides is passed through a column of inert support particles coated with actinide extractive organic ligands. Successful implementation results in the separation of the effluent stream into a small volume with high actinide concentrations and an aqueous effluent stream decontaminated of most alpha activity. This process has been tested on the high-concentration (5 to 8M) hydrochloric acid streams from the solvent extraction process. The synthesis of new actinide ligands in large amounts and full-scale demonstration at TA-55 are required. Ligand synthesis, full-scale demonstration, and plant-scale deployment will require $1 million over 2 years. Waste-avoidance type: internal recycle. (Source, NMT-2)

2.4.5.1.3. Option TRUCaus.3. Improved Dissolution Technologies. Increasing the recovery efficiency of the aqueous chloride process is dependent on the ability to dissolve the feedstock matrices more fully to free the plutonium. Improved dissolution will decrease the quantity of residues that must be reprocessed or discarded, thus reducing the TRU waste stream. Additional investigation and R&D are needed to identify and optimize new dissolution technologies. This is a relatively new area of research and will be more fully developed at a later date. Waste-avoidance type: internal recycle. (Source, NMT-2)

Performance Measures

1. Number of hydroxide cakes with plutonium concentrations less than the STL values.

2. Number of hydroxide cakes requiring immobilization or reprocessing.

2.4.6. Acidic Liquid Waste

Acidic liquid waste is derived from the processing of plutonium feedstock employing nitric acid for matrix dissolution. Following oxalate precipitation, the effluent is sent to the evaporator, where the overheads are removed and sent to the TA-50 RLWTF for further processing via the acid waste line. Evaporator bottom sludge is cemented into 55-gal. drums for disposal. Figure 2-9 shows the process map for the Nitric Acid Recovery Process. It is estimated that when the improvement options listed on this process map are implemented, a 90% reduction in this waste stream can be achieved.

2.4.6.1. Improvement Options

2.4.6.1.1. Option TRUAcid.1. Scintillating In-Line Alpha Counter. The scintillating in-line alpha counter is a real-time process monitor developed to measure process solution concentrations. Measuring will allow operators to make rapid decisions concerning the desirability of recycling process solutions to further reduce effluent concentrations. This real-time, decision-making capability can reduce the quantity of evaporator bottom

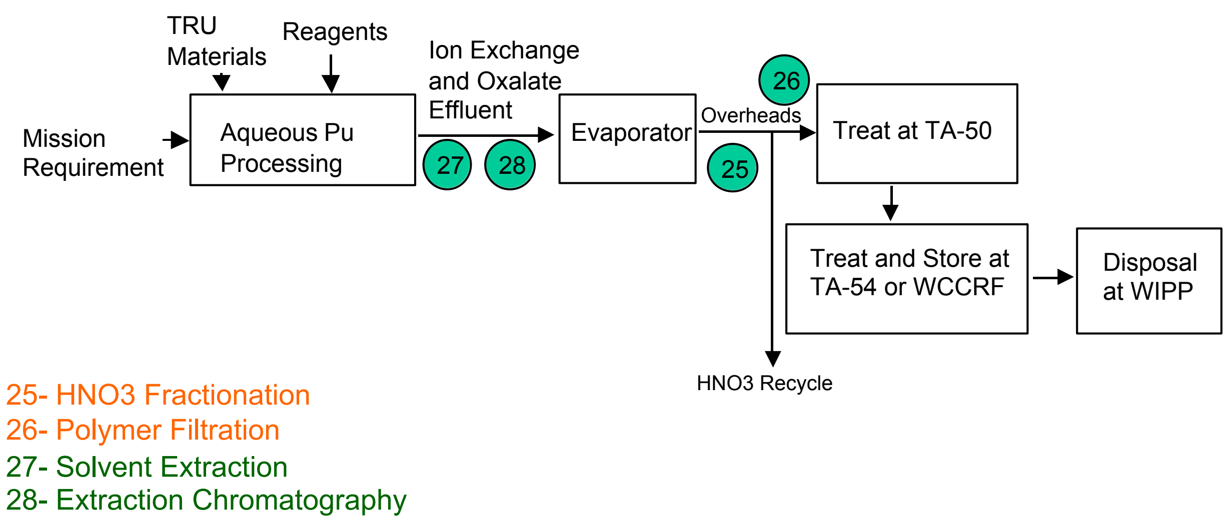


Fig. 2-9. Process map for acidic liquid TRU waste.

sludges that exceeds the STLs and require immobilization or reprocessing. By installation of multiple monitors at various points in the process stream, plutonium recovery rates can be optimized. Optimization of the plutonium recovery rates will reduce the amount of plutonium present in the evaporator bottoms requiring cementation, thus reducing the total volume of TRU waste generated. This technology already has been developed using 94-1 Residue Stabilization for application in the aqueous chloride process. EM/ESO funding is being used to develop and implement the technology by NMT-2 and CST-13 on the nitric acid process. Waste-avoidance type: internal recycle. (Source, NMT-2)

2.4.6.1.2. Option TRUAcid.2. Nitric Acid Distillation. Installation of a fractional distillation column currently is underway. This will provide the capability to concentrate the spent 3 to 7 M of nitric acid waste stream from the aqueous nitrate process to 12 to 15 M for reuse. Reuse of the nitric acid will reduce the nitrate concentration in the TA-55 acid waste stream, allowing the TA-50 RLWTF to achieve the National Pollutant Discharge Elimination System (NPDES) permit level for nitrate ion. This is a significant improvement that will help satisfy a compliance order from the NMED. Waste-avoidance type: internal recycle. (Source, NMT-7)

2.4.6.1.3. Option TRUAcid.3. Polymeric Filtration. This process selectively recovers valuable or regulated metal ions from process or wastewater. Water-soluble chelating polymers are designed to bind selectively with metal ions in aqueous solutions. The polymers have a sufficiently large molecular weight so that they can be separated and concentrated using commercially available ultrafiltration technology. A series of tests with these units has been performed at TA-55 on actual wastes, including ^{238}Pu. A pilot-scale system has been installed in a PF-4 glovebox for demonstration testing. Three of four units now may be deployed at TA-55. The cost to implement a single polymer filtration unit is $750,000. This technology also may be deployed on the RLWTF effluent processing upgrade program at TA-50. Waste-avoidance type: internal recycle. (Source, NMT-7)

2.4.6.1.4. Option TRUAcid.4. Improved Dissolution Technologies. Increasing the recovery efficiency of the nitrate process is dependent on the ability to dissolve the feedstock matrices more fully to free the plutonium. Improved dissolution will decrease the quantity of residues that must be reprocessed or discarded, thus reducing the TRU waste stream. Additional investigation and R&D is needed to identify and optimize new dissolution technologies. This is a relatively new area of research and will be more fully developed at a later date. Waste-avoidance type: internal recycle. (Source, NMT-2)

2.4.6.1.5. Option TRUAcid.6. Electrochemical Destruction of Nitrates. Electrochemical oxidation technology is being applied to reduce the nitrate ion concentration in the TA-50 RLWTF outfall effluent stream. The conversion of nitrate to nitric oxides will contribute to meeting the NPDES permit level for nitrate ion. When coupled to the nitric acid distillation column being installed upstream at TA-55, the application of these technologies will result in a significant decrease in the nitrate ion concentration required to satisfy a compliance order from the NMED. Waste-avoidance type: treatment. (Source, CST-7)

Performance Measures

- Monitor the volume of aqueous waste discharged to the RLWTF.
- Monitor the amount of TRU waste generated at the RLWTF.

3.0. MIXED LOW-LEVEL WASTE (MLLW)

3.1. Definition

Mixed waste is any waste containing both hazardous and source, special nuclear, or by-product materials. For mixed waste to be considered MLLW, it must meet the definition of LLW. Thus, MLLW contains both radioactive and RCRA waste. Because MLLW contains radioactive components, it is regulated by DOE Order 5820.2A (DOE, 1988). Because it contains RCRA waste components, it is also regulated by the State of New Mexico through the site's operating permit, FFCO/STP (NMED 1995), and the EPA. Materials in use that will be RCRA waste upon disposal are defined as hazardous materials.

Most of the Laboratory's routine MLLW results from Stockpile Stewardship and Management and from R&D programs. Most of the nonroutine waste is generated by off-normal events such as spills (Environmental Restoration and Waste Management Legacy operations also produce MLLW; however, this is not included in this roadmap). Typical MLLW items include contaminated lead shielding bricks, R&D chemicals, spent solution from analytic chemistry operations, mercury cleanup kit waste from broken fluorescent bulbs and mercury thermometers, circuit boards from electronic equipment removed from a TRU waste radiation area, discarded lead-lined gloveboxes, and some contaminated water removed from sumps.

3.2. Waste-Type Description

MLLW is generated in RCAs. Hazardous materials and equipment containing RCRA materials, as well as mixed low-level materials, are introduced into the RCA as needed to accomplish specific activities. In the course of operations, hazardous materials become contaminated with LLW or become activated, becoming MLLW when the item is designated as waste. There are seven major MLLW streams: circuit boards, gloveboxes, lead parts, R&D chemicals, personnel protective equipment, fluorescent tubes, and waste generated from spills and spill cleanup.

The top-level process map for MLLW is shown in Fig. 3-1. Upon generation, MLLW typically is transferred to a satellite storage. Where possible, mixed low-level materials are surveyed to confirm that they are radiologically contaminated. If decontamination will eliminate either the radiological or hazardous component, they are then decontaminated and removed from the MLLW category. Otherwise, upon receipt of proper waste and Department of Transportation documentation, MLLW is transferred to Solid Waste Operations (Area L or Area G, TA-54) for storage, bulking, and transportation. From Area L or Area G, it is sent to commercial and DOE MLLW treatment and disposal facilities. It is treated/disposed of by various processes, including, but not limited to, segregation of hazardous components, macroencapsulation, or incineration.

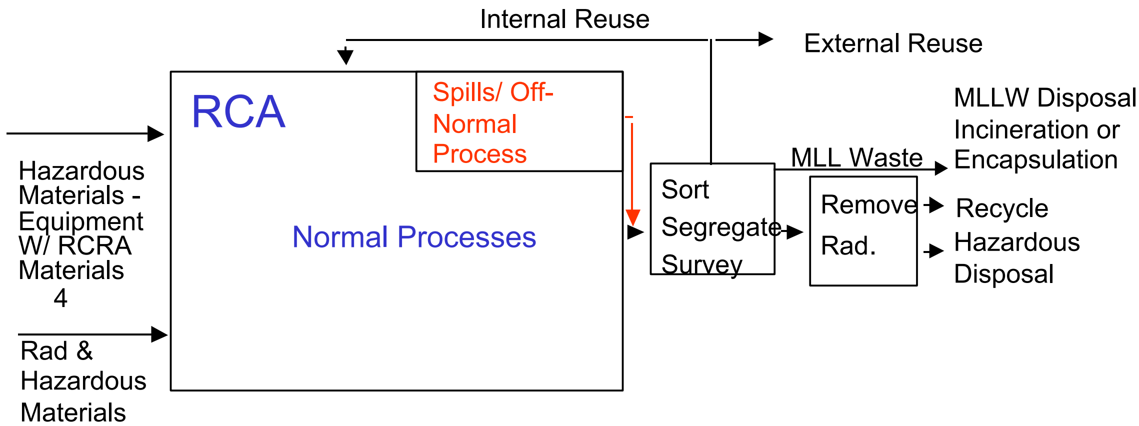


Fig. 3-1. MLLW process map.

In some cases, the Laboratory procures spent mixed low-level materials from other DOE/commercial sites to avoid creating new MLLW. For example, LANSCE is designing several new beam stops and shutters from lead. Rather than fabricating these from virgin, uncontaminated lead, LANSCE will receive these parts at no expense from GTS Duratek (formerly SEG), a company that processes contaminated lead from naval nuclear reactor shielding. This reduces costs because Duratek will fabricate parts at no cost (they save money because fabrication costs are much less than MLLW lead disposal costs).

The MLLW generated by division at the Laboratory is shown in Fig. 3-2. (Environmental Restoration and Waste Management Legacy operations also produce MLLW; however, this is not included in this roadmap).

The actual generation of MLLW as a function of time has been dropping steadily. A comparison of the actual generation of MLLW [in cubic meters (non-ER, nonlegacy)] is shown in Fig. 3-3.

The largest waste streams are spills, other, debris, gloveboxes, and personnel protective equipment (PPE). These waste streams constitute ~80% of the MLLW waste type and are the primary targets for elimination. The waste streams were determined from 1995–1998 waste generation. The individual waste streams are described briefly below. The relative size of the various MLLW waste streams is shown in Fig. 3-4.

Spills (15.4 m^3): Spills occur randomly across the Laboratory; no single RCA or group dominates this waste stream. Spill waste includes the spilled material, spent-spill cleanup kit, containment barriers, and PPE worn during spill cleanup.

Other (6 m³): This consists of decontaminated water, decontaminated fluids, and miscellaneous other materials.

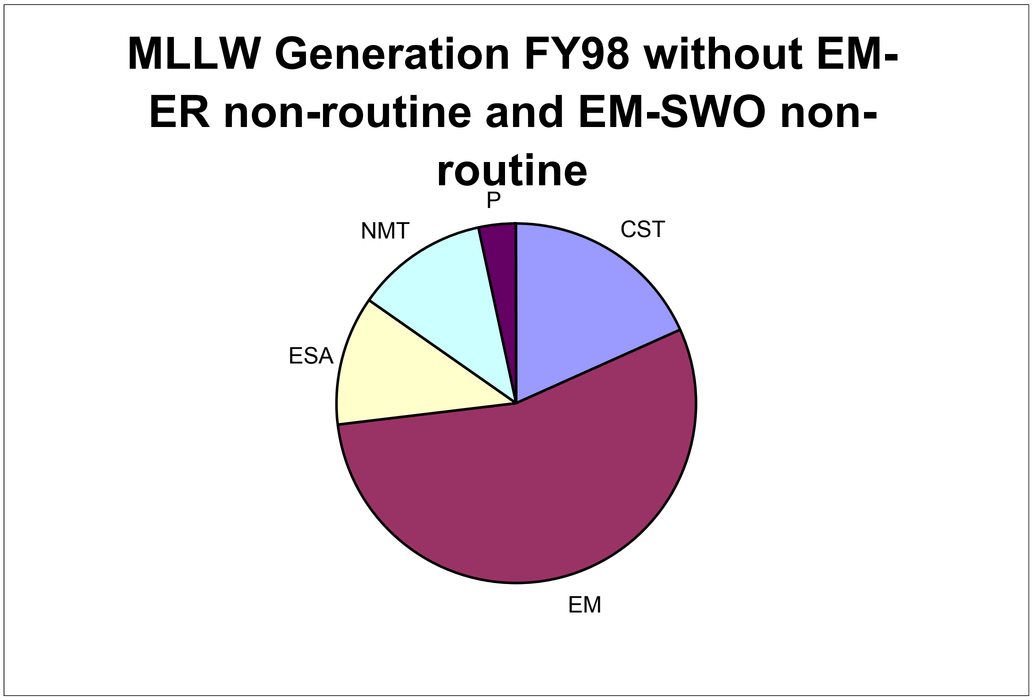


Fig. 3-2. MLLW generation for FY98 by division.

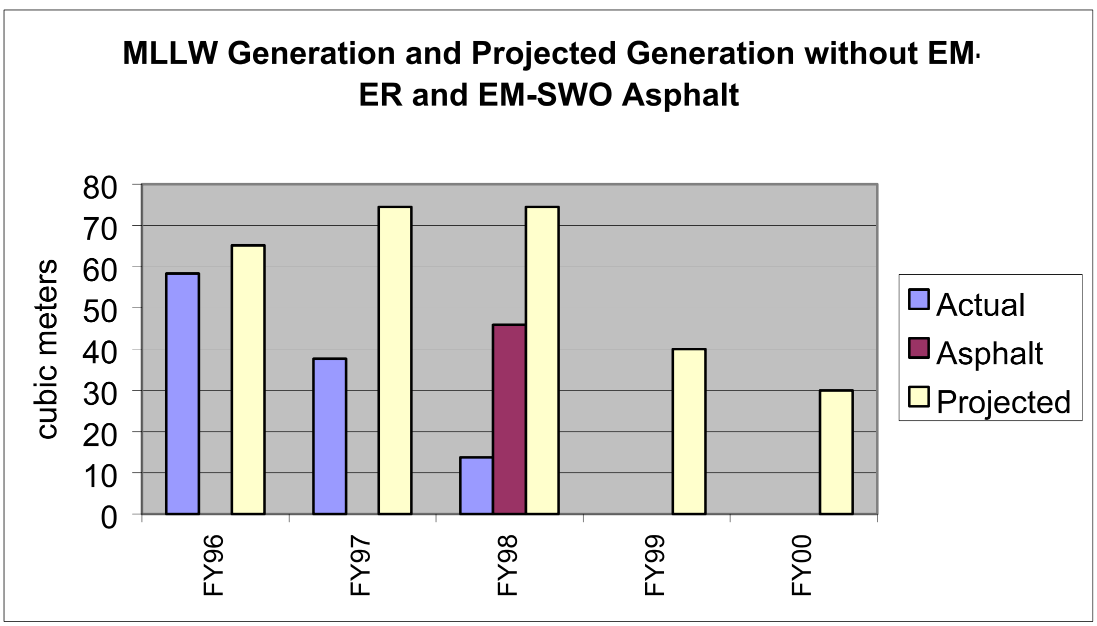


Fig. 3-3. MLLW generation and projected generation.

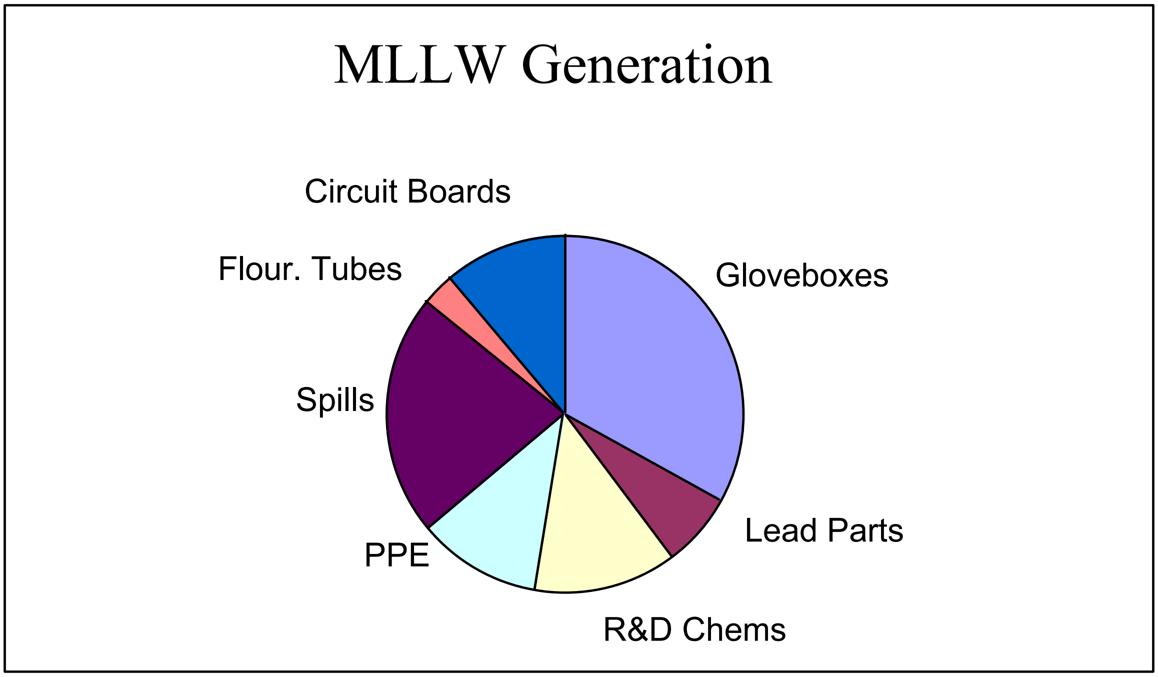


Fig. 3-4. MLLW generation breakdown.

Debris (4.1 m³): Debris is contaminated copper pipe with lead solder joints, contaminated plastic sheets, duct tape, hoses, and used pump housings.

Gloveboxes (3.8 m³): Gloveboxes are mixed waste because they are internally contaminated with hazardous constituents and radioisotopes or they have lead shielding welded into their walls.

PPE (3.8 m³): Personnel protective equipment (clothing) is used to process mixed low-level materials and is disposed of as MLLW. It is normally incinerated by an offsite vendor.

R&D Chemicals (2.9 m³): Spent chemicals from research projects and production operations are generated in milliliter to several-liter quantities and are consolidated into 30-gal. volumes before being sent offsite for disposal (typically incineration).

Lead (2.2 m³): This waste stream comprises activated or surface-contaminated lead shielding, contaminated lead paint, and lead components. Lead normally is sent to Envirocare, Inc. for encapsulation and land disposal, although surface-contaminated lead parts are decontaminated and recycled.

Circuit Boards (2.1 m³): Circuit boards from electrical equipment contain lead solder. If contaminated with radioactive materials, they are disposed of as MLLW.

Fluorescent Tubes (1.4 m^3): Tubes that become activated in an RCA must be disposed of as MLLW. This typically occurs only at LANSCE (in the Proton Storage Ring).
The generation of MLLW has decreased dramatically over the past 4 years. This success is largely due to process modification to avoid generation of MLLW and material substitution. Generation of MLLW now is dominated by accidental spills.

MLLW is projected to cost an average of $101,484/m^3 to characterize, treat, and dispose of in FY99. EM/SWO will spend a total of $5,684,000, managing newly generated MLLW in FY99. Table 3-1 summarizes the Laboratory's typical unit costs for MLLW disposal. Waste is disposed of either by incineration or by macroencapsulation and land disposal. Macroencapsulation involves potting the waste (typically solid parts) in a suitable plastic and creating a barrier around the waste.

3.3. Issues and Constraints

3.3.1. Waste without a Disposal Path

Several forms of MLLW cannot be disposed of because no vendors will accept that material. The Laboratory has very few MLLW treatment systems; these are very expensive to permit (about $100,000 per treatment process). Consequently, several Laboratory wastes must be stored awaiting a disposal option. DOE/AL has established a special procedure for obtaining approval to produce a waste that cannot be disposed of. Examples of such waste include most mercury-contaminated radiological materials and RCRA waste combined with TRU isotopes having a specific activity >10 nCi/g.

Table 3-1. Approximate costs for MLLW streams. (Source, John Kelly, Solid Waste Operations)

Waste Type	Treatment Method	Treatment and Disposal Cost	Transportation Cost
Activated or inseparable lead	Macroencapsulation	$425/ft^3	$5000 per shipment
Surface-contaminated lead (amenable to onsite decon)	Decontamination at TA-50	Treatment—$1/lb	Nominal
Surface-contaminated lead (for offsite recycling)	Standard decontamination methods (bead blasting, acid dip, etc.) followed by recycling	~ $2/lb, depending on form	$5000 per shipment
RCRA waste-regulated solvents with rad components	Fuel recycling at Diversified Scientific Services, Inc. (DSSI)-permitted boiler	$75–$200/gal. Actual costs depend on levels of radionuclides, metal content, % water, and halogen content	$5000 per shipment
Activated RCRA	Macroencapsulation	$425/ft^3	$5000 per shipment

waste components			
Fluorescent tubes with mercury	Amalgamation followed by landfill	$3000/ft^3	$5000 per shipment
Printed circuit boards	Macroencapsulation	$425/ft^3	$5000 per shipment

3.3.2. Listed Wastes

In several cases, the Laboratory uses solvents (toluene and methylene chloride) in very small quantities, which once they become waste are RCRA-listed wastes because of their toxicity. Because these are listed wastes, it does not matter how little of these appears in the waste stream: the stream is still a listed waste (presuming it also has a radiological component). *De minimus* thresholds for some listed wastes would reduce the quantities of MLLW generated at the Laboratory. The EPA is proposing new rules for small quantities of these chemicals that would give the Laboratory more flexibility in minimizing these wastes.

3.3.3. Below-Background Radiological Contamination

Every waste item leaving an RCA is assumed to be radiologically contaminated unless

1. acceptable knowledge exists that the item was never exposed to radiological material or

2. it can be surveyed and declared nonradiological according to the limits established in DOE Order 5400.5 (note: this order only sets limits for surface contaminated items, and thus, porous materials cannot be surveyed and released this way).

The ANSI has proposed a new standard (ANSI N13.12) that would establish limits for releasing potentially volume-contaminated items leaving RCAs. DOE acceptance of this standard would enable more accurate waste segregation and avoid generation of MLLW with near-zero radiological contamination.

3.3.4. Radiological Characterization Uncertainty

A significant fraction of MTRU waste is actually MLLW. However, because of radiological characterization uncertainty (resulting from radiation background where characterization occurs and from the capability of the instruments used), it is not possible to distinguish MTRU waste from MLLW when the specific activity exceeds 10nCi/g. To avoid adverse findings from a misclassification of waste, most waste >10 nCi/g is classified as MTRU. However, before being shipped to WIPP, all MTRU waste will be assayed accurately for specific activity. At that time, misclassified MTRU waste will become MLLW and must be disposed of as such. To avoid the expense of this extra characterization, Laboratory facilities must perform more accurate radiological assays.

3.3.5. Control of Materials, Which Will Be RCRA Waste at Disposal

There is limited guidance for minimizing hazardous materials brought into RCAs, which will be RCRA waste once discarded.

3.4. Waste Streams

The waste streams defined in Section 3.3.3 arise from processes at various Laboratory sites and in some cases are interrelated. For example, MLLW in the category "other" comes from decontamination processes. Because this stream is captured in other process flow maps, it is not called out explicitly with a map of its own. Similarly, contaminated PPEs and contaminated equipment are generated in many processes; these streams are captured in other process charts. Process maps have not been developed for the smaller waste streams.

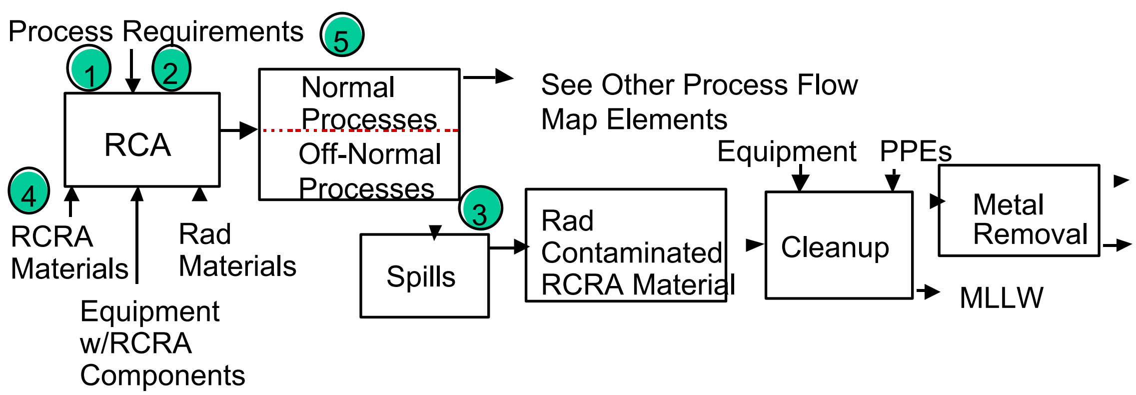
The waste-stream analyses are organized into (1) a waste-stream description, including a summary of recent waste minimization successes; (2) waste-stream reduction options; and (3) waste-stream performance measures, objectives, and time frames. (Note: waste-stream performance objectives and time frames are not included in this version of the roadmap.) The waste-stream reduction options include procedural changes requiring no funding, funded projects, well-defined but unfunded projects, and waste reduction concepts that require further definition.

3.4.1. Spills

Spills generate more than one third of the total annual MLLW at the Laboratory. Typical spills include broken mercury thermometers, broken lamps or blown mercury lamps, and water spills that enter contaminated areas or sumps. The process map and identified options are shown in Fig. 3-5. Programmatic mission needs define the work that must be accomplished in an RCA. To accomplish programmatic work, an RCA facility is configured and outfitted to accommodate processes involving radioisotopes and hazardous chemicals. Many of the Laboratory's RCAs process TRU waste materials (plutonium, americium, etc.). Because these materials are very difficult to detect and because the DOE has a no-rad-added policy, any RCRA spill debris leaving TRU waste RCAs is assumed to be MLLW. (The no-rad-added policy states that whenever DOE mission activities could have added nonnatural radioactivity to a material, that material shall be treated as radiologically contaminated. This policy was modified recently by DOE Order 5400.5, which set free-release limits for certain nonporous materials that are only surface contaminated.) Once a spill occurs, it is cleaned up using the appropriate spill cleanup kit and procedure. The spilled material, the cleanup materials, the PPE worn by the cleanup team, and the material used to cordon off the spill area are all disposed of as MLLW.

Spill waste minimization actions taken to date include

- replacement of hazardous, high-mercury fluorescent bulbs for nonhazardous, low-mercury bulbs in the LANSCE Proton Storage Ring (1.4-m^3 annual avoidance);
- improved spill prevention in hazard control plans and as part of safe work practices [part of Integrated Safety Management (ISM)];
- institution of a procedure for periodic monitoring of the radiological liquid sump in the radiation-machining area of the main machine shop to detect buildup of lead; and
- substitution on nonhazardous chemicals in several systems and research activities.



1. Eliminate Mercury Thermometers
2. Eliminate RCRA Fluorescent Bulbs
3. Improve Spill Prevention Training
4. Label All RCRA Materials
5. Further Reduce RCRA Size

Fig. 3-5. Process map for spills.

3.4.1.1. Improvement Options. From an operational perspective, spills can be divided into two categories: (1) accidental spills, such as a containment failure or a dropped bottle of chemicals; and (2) leaks, where water or a hazardous chemical may leak from a storage vessel or system into a containment area. Limiting the number and severity of accidental spills is being addressed by the safe work practices and hazard control plans, which are elements of ISM. The consequences of spills can be reduced by further substitution of nonhazardous materials for hazardous materials, improvement of secondary containment for certain processes, and treatment to remove metals from aqueous spills.

3.4.1.1.1. Mercury Thermometer Replacement. Replace the mercury thermometer in RCAs with digital or alcohol-based thermometers. Cost: $100,000. Funding source: Waste Management (WM) Upstream Treatment Project. Annual waste avoidance: 0.3 m^3/year or $30,000/year. ROI: 33%. (Note: Many mercury-contaminated radiological wastes cannot be disposed of commercially and currently are stored at TA-54. The Waste Management Program is funding development of a water-soluble polymer treatment to remove mercury from these wastes.) Waste-avoidance type: material substitution.

3.4.1.1.2. Nonhazardous, Low-Mercury Fluorescent Bulbs in All RCAs. Broken fluorescent tubes are treated as mercury spills. Replacement of current hazardous bulbs with nonhazardous bulbs would eliminate this waste stream. This replacement could occur as current bulbs are replaced at the end of their typical lifetime, 3 years. Cost: $0. Annual avoidance: 0.1 m^3/year. ROI: not applicable. (Implementation of this option requires a sitewide prohibition on the use of hazardous fluorescent bulbs—this is underway as a hazardous waste minimization project.) Waste-avoidance type: material substitution.

3.4.1.1.3. Further Improvements in Hazardous Material Spill Prevention/Cleanup. This concept is being developed. Waste-avoidance type: source reduction.

3.4.1.1.4. Controling, Inventorying, and Labeling of Hazardous Materials in RCAs. This concept is being developed (overlaps with hazardous waste minimization options). Waste-avoidance type: source reduction.

3.4.1.1.5. Further Reduce RCA Size. This is a follow-on to an FY96–97 radioactive waste minimization project. Implementation details are being developed (overlaps with LLW reduction options). Waste-avoidance type: source reduction.

Performance Measures

1. Volume of annual spills.
2. Volume of secondary waste generated by spills (contaminated equipment, PPEs, etc.).
3. Volume of spill waste without a disposal path.

3.4.2. Gloveboxes

Many gloveboxes are lined with high-atomic-number material (such as lead) to protect workers from radiation exposure. Once such gloveboxes are radiologically contaminated, they become mixed waste, even though the lead is welded into the glovebox walls and is not in contact with radioisotopes. In a few cases, the interior of a glovebox also is contaminated with hazardous materials, but in most cases, this contaminant can be removed. The process flow map for gloveboxes is shown in Fig. 3-6. A mission program requires that certain work be accomplished only in a glovebox. Shielding is necessary to minimize the radiation dose to workers. Glovebox design standards require that the shielding be lead and that it be welded into the front glovebox wall. Shielding is welded in, rather than hung from, the front of the box to minimize and smooth the outer surface of the box. If the outside becomes contaminated, only a minimum, smooth surface needs to be decontaminated. Lead was chosen as the shielding material because of its formability, shielding properties, and low cost.

Next, the glovebox is fabricated, installed, and used. Either the glovebox will become "worn out" or mission programmatic needs will change and the space that the glovebox occupies will be needed for another process. Most often, the new process requires a new glovebox. If the spent glovebox becomes sufficiently worn out that it is unsafe to work in, it will be disposed as MTRU waste (or sent to the DVRS at TA-54 once that facility becomes operational). Non-worn-out gloveboxes are decontaminated electrolytically (either in TA-55, CMR, or TA-50); the lead then is removed by breaking the stainless steel welds (at TA-50 facility). The lead is surveyed, free-released under DOE Order 5400.5, and recycled through a commercial vendor. Gloveboxes that are not worn out and fit a LANL or other organizational requirement are diverted for reuse after they have been decontaminated. Reuse can be either in a LANL facility or in Russia or

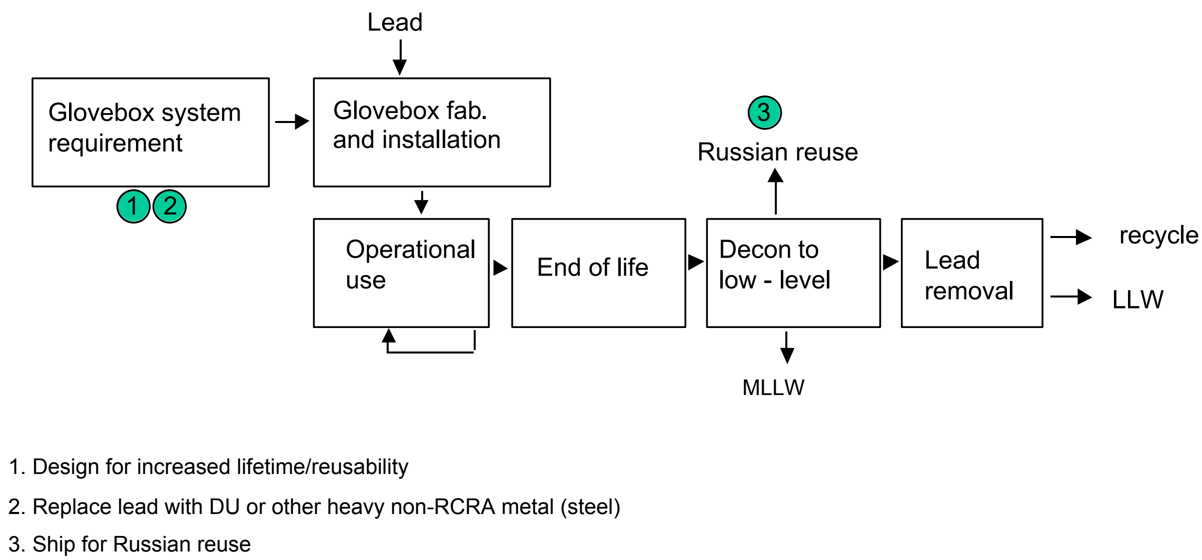


Fig. 3-6. Process map for gloveboxes.

Kazakhstan, at a facility conducting joint research under DOE sponsorship. (See the TRU waste and LLW sections for a more detailed discussion of glovebox waste minimization.)

Major improvements to date to minimize glovebox MLLW include the following.

1. Development of a facility and capability to remove lead from gloveboxes by breaking the stainless steel weld (TA-50, CST-7 Decontamination Team). Typical cost for a two-station glovebox is $2000.

2. Reuse of gloveboxes inside TA-55.

3.4.2.1. Improvement Options

3.4.2.1.1. Substitution of a Nonhazardous Material for Lead. Although lead has good shielding/price/workability properties, gloveboxes could be manufactured with stainless steel walls that are two and a half times thicker and achieve the same radiation shielding performance. This likely would cost less than the current practice of welding a stainless steel sandwich around lead. Lawrence Livermore National Laboratory's (LLNL's) gloveboxes are fabricated with such a thick stainless steel wall. Another option is to replace lead with tungsten beads or a tungsten-powder-loaded thermal-set polymer. Further work is required to develop cost and waste-avoidance numbers for this option. In addition, personnel safety, radiation exposure, and impact on the ease of work in the glovebox also must be considered. Waste-reduction type: material substitution.

3.4.2.1.2. ***Design Gloveboxes for Longer Life.*** Longer glovebox life has two components: (1) standardization of the box design so that new processes routinely can be moved into used gloveboxes and (2) enhanced protection of the glovebox interior surfaces so that they do not become contaminated by hazardous materials and are more resistant to corrosives used in the glovebox. Further work is required to develop cost and waste-avoidance numbers for this option. Waste-reduction type: lifetime extension.

3.4.2.1.3. ***Russian Reuse of Gloveboxes.*** LANL will spend almost one billion dollars over the next 10 years upgrading radiological facilities to accomplish the stockpile stewardship and management missions. The glovebox systems in several facilities will be replaced. The excessed systems would have to be disposed of as MLLW. To avoid this waste generation, LANL has negotiated agreements with the International Science and Technology Center to transfer this equipment to Russian and Kazakhstani laboratories that operate radiological facilities and can use this equipment. Status: A pilot shipment has been sent to Mayak using 1998 Generator Set-Aside Fee (GSAF) Program funds. EM/WM Upstream Treatment Activity funds will be used to ship three SeaLand containers of excess electronics and gloveboxes in FY99. Cost: \$10,000/SeaLand container. Funding source: 98 GSAF Program and WM Upstream Treatment Project (in FY99 and beyond). Waste avoided: 30 m^3 of the MLLW. ROI: 330% (note that the avoided waste cost is calculated by assuming that the gloveboxes would otherwise be disposed of as MLLW). Waste-reduction type: reuse. This option is related to the MLLW option to reuse electronics (containing lead circuit boards) and an LLW option to reuse excess equipment from RCAs.

Performance Measures

- Average life of lead-lined gloveboxes.
- Number of lead-lined gloveboxes reused.
- Number of lead-lined gloveboxes where lead is removed or recycled.
- Number of lead-lined gloveboxes disposed of as MTRU waste.

3.4.3. Lead/Cadmium Shields

The use of lead for shielding is common in laboratory RCAs. Lead is inexpensive and easily worked or machined. Lead is most often used as an x-ray or gamma shield and frequently is combined with cadmium for additional x-ray absorption. Shielding can be used to isolate detectors and/or people from radiation sources. To be efficient, shielding is placed close to its source. The process map with options is shown in Fig. 3-7.

Major current improvements to minimize shielding lead and cadmium MLLW include the following.

1. Grit blasting of large lead parts (such as bricks) and lead recycling by the CST-7 Decontamination Team at TA-50. This service is available to waste

generators on a recharge basis. Solid Waste Operations no longer accepts as waste those lead parts that can be decontaminated.

2. Electrochemical processing of surface-contaminated lead pieces (such as small beads) by the CST-7 Electrochemical Processing Team at TA-50. This process is appropriate for small lead parts that cannot be grit blasted because of their size.

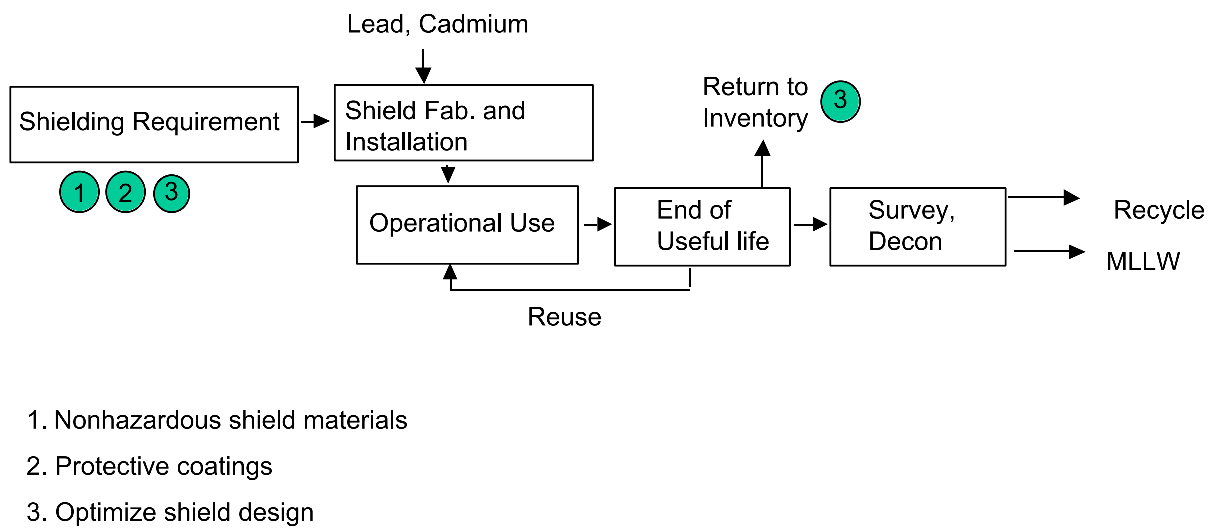


Fig. 3-7. Process map for shields.

3.4.3.1. Improvement Options. There are many options available to improve the lead/cadmium shield waste stream. These options are detailed in the subsections below.

3.4.3.1.1. Nonhazardous Shielding Materials. Available lead and cadmium substitutes are a tungsten-loaded polymer and rare-earth-oxide powders. The tungsten-loaded polymer is typically 10 times more expensive than lead; however, it may be more cost effective for applications where contamination is likely to occur, such as inside gloveboxes, as a liner in gloves, in areas with frequent contamination releases, and for shapes that cannot be easily decontaminated by grit blasting. Further work is required to develop cost and waste-avoidance numbers for this option. The next step likely will be a pilot to determine cost/effectiveness performance. Waste-reduction type: material substitution.

3.4.3.1.2. Protective Coatings. Lead and cadmium are the primary metals used for radiation shielding in RCAs. Several commercial coatings are available to protect such metals from radiological contamination. Coatings can be removed from the lead as it leaves the RCA; the lead can be recycled and the coating disposed of as LLW or MLLW.

Status: unfunded. Further work is required to develop cost and waste-avoidance numbers for this option. Waste-reduction type: segregation.

3.4.3.1.3. Optimal Shielding Designs. Many shielding systems are not based on scientific designs but rather on operating experience. Operating experience tends to stack the maximum amount of lead into the available space and then measure to confirm that the shielding is sufficient. For shields requiring more than some threshold weight of lead, a science-based shielding design could be required. This would enable the use of a reduced but effective amount of lead. Cost: unknown. Waste avoided: unknown. ROI: unknown. Waste-reduction type: source avoidance.

Proposed Implementation. Conduct a survey of radiation shielding. Calculate the extent of over-shielding. Compare the shielding computation costs vs excess shielding decontamination costs and decide whether to establish a Laboratory requirement for optimal shielding for shields above some lead-weight threshold.

Performance Measures

1. Quantity of lead/cadmium in RCAs.
2. Quantity of lead/cadmium procured each year for RCA use.
3. Quantity of lead/cadmium recycled.

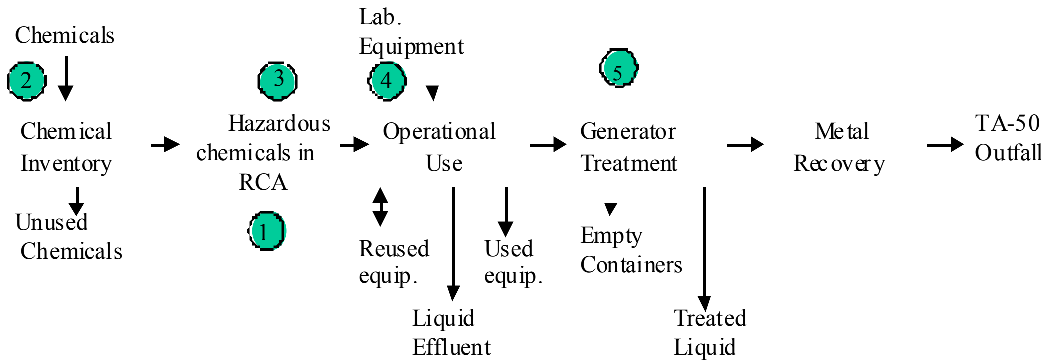
3.4.4. Research Chemicals

The process map for research chemicals is shown in Fig. 3-8. A wide range of hazardous chemicals is stored in RCAs. The chemicals are mixed with radiological materials to meet mission work requirements. Spent chemical solutions and the equipment that contained them are potentially MLLW. Sometimes the equipment is not MLLW because of the RCRA waste empty-container rule. In that case, the equipment can be disposed of as LLW. If the RCRA waste component cannot be eliminated by the waste generator or by electrochemical processing, the spent solution is designated as MLLW and sent through satellite and less-than-90-day storage areas to SWO, Area L, TA-54. MLLW chemicals are bulked at Area L and sent to DSSI.

Major improvements to date to minimize research chemical MLLW include the following.

1. Generator neutralization of corrosives and transmission to the TA-50 RLWTF.

2. Elimination of acetyl acetone and dioxane from medical isotope extraction processes.



1. Mediated Electrochemical Oxidation
2. Material Substitution
3. Microchemistry
4. Oil-Free Pumps in RCAs
5. Palladium Membrane Reactor

Fig. 3-8. Process map for research chemicals.

3. Reduction of sample sizes at NMT-1 analytic chemistry operations through installation of a new solvent extractor.

3.4.4.1. Improvement Options. There are many options available to improve the research-chemicals waste stream. These options are detailed in the subsections below.

3.4.4.1.1. Option MLLW41. Mediated Electrochemical Oxidation. Each year, analytic chemistry activities produce several thousand small containers of organic solvents and radioactive metals in solution. Toluene, methanol, and methylene chloride are the primary solvents. These are disposed of as MLLW and cost \$200,000 to \$500,000/m^3. The high costs result from the need to characterize and bulk these chemicals into 30-gal. drums and the high cost of disposal. Mediated electrochemical oxidation's (MEO's) effectiveness has been demonstrated at LLNL and Pacific Northwest National Laboratory (PNNL). MEO is used in a production mode by the French nuclear industry to recover radioisotopes from a wide range of spent materials. An MEO system includes an electrochemical cell with nitric acid electrolyte solution, a mediating metal (in our case, cerium), and a plutonium-organic solvent feed material. (Other feed materials are possible as well—finger cartridge filters, contaminated vacuum pump oil, contaminated cheese cloth, etc.). The electrocell doubly reduces the cerium, the electrocell oxidizes the organic solvent, and the plutonium dissolves into the nitric acid solution.

After all of the organic solvent has been oxidized to nonhazardous materials, the plutonium-nitric acid solution is removed. The plutonium will be reclaimed and the nitric acid neutralized, dried, and disposed of as mixed waste (not because any RCRA waste remains but because toluene and methyl chloride are "listed" wastes; all waste streams from treating a listed waste remain a listed waste, even though the original listed chemical is completely gone). The MEO unit will be installed in the CMR building (NMT-1). It can process 4 L of spent chemicals per day and a greater volume of MLLW-contaminated components. MEO should eliminate this type of MLLW generation in the CMR building. Status: funded by the EM/WM Upstream Treatment Activity. An MEO unit is on site and should be operational in the CMR by mid-FY00. Cost: $900,000. Waste avoided: 2 m^3/year. ROI: 22.5%. Waste-avoidance type: treatment. (MEO is also under consideration as a TRU waste minimization solution for mixed and cellulosic wastes.)

3.4.4.1.2. Materials Substitution. By analyzing the organic components of MLLW, it is possible to determine which organic chemicals are responsible for mixed waste. The processes whereby these chemicals are mixed with radioisotopes can be analyzed and nonhazardous chemicals can be substituted. Status: under development. Waste-avoidance type: material substitution.

3.4.4.1.3. Microchemistry. Many analytic chemistry and chemical research processes that generate MLLW use significantly more chemicals than are necessary. In recent years, microchemical procedures that use very small chemical volumes have been developed. The Environmental Stewardship Office has piloted microchemistry operations in NMT-1 with the installation of a solvent extractor. A more complete evaluation of Laboratory chemical practices should identify additional waste minimization opportunities. It is expected that microchemical training will be necessary, in addition to purchasing microchemical instruments. Status: pilot complete. Next steps under development. Waste-avoidance type: source reduction.

3.4.4.1.4. Oil-Free Pumps in RCAs. Vacuum pumps that support radioisotope processing and analysis can become contaminated. This can result in MLLW pump oil if the oil includes RCRA constituents or if these wastes have accumulated in the oil during operation. Converting to oil-free pumps would eliminate the source of this waste. Oil-free pumps come in two varieties: those that use no oil and those that use oil to lubricate bearings. An evaluation of RCA vacuum pumping needs and available pump technology will determine which oil-based pumps can be eliminated. Based on this, a policy can be developed to preclude the use of oil-based vacuum pumps in RCAs. Status: under development

3.4.4.1.5. PMR for Liquid Tritiated Wastes. Tritium research and operations generate a small volume of tritium-contaminated organic solvents. The organic component can be oxidized and the tritium recovered using the Palladium Membrane Reactor (PMR) system. The PMR combines hot carbon monoxide with the organic solvent in the presence of a palladium membrane. The liberated tritium (in fact, all hydrogen isotopes) permeates the membrane and is separated by cryogenic fractionation. Status: a pilot PMR system exists, a pilot test is required, and a system upgrade is necessary to achieve full operation. This project is unfunded. Note that this same system can be used to recover tritium from tritiated process water.

3.4.4.1.6. Hydrothermal Processing. See the discussion in the TRU waste section.

Performance Measures

1. Quantity of mixed low-level research chemicals disposed of annually as RCRA waste by listed type (F, P, U, etc.).

2. Average volume of hazardous chemical used in each experimental procedure.

3.4.5. Electronics

Because most electronics have printed circuits that contain lead, those electronics become MLLW if they become contaminated with radiological materials. In almost all cases, it is extremely unlikely that the electronics will be exposed to radiological contamination. However, in most cases, there is no acceptable proof that the electronics were never contaminated. For beta- and gamma-emitting radioisotopes, contamination is easy to detect using standard radiological assay instruments. However, for alpha-emitting isotopes, it is very expensive to measure the activity of every surface on a circuit board. In addition, disassembly and measurement typically destroy the equipment. Today, most electronics are disassembled and their circuit boards are surveyed and then sent to be commercially recycled. MLLW circuit boards are sent to Envirocare where they are encapsulated in plastic and buried in an LLW landfill. The process map for the electronics waste stream is shown in Fig. 3-9.

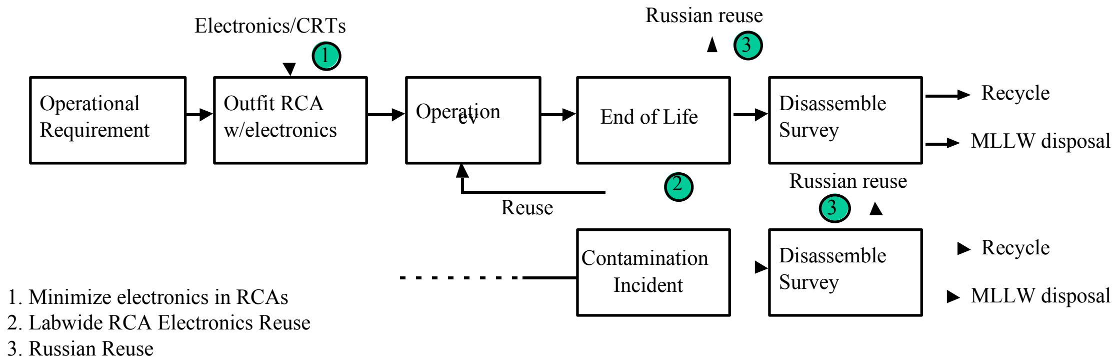


Fig. 3-9. Process map for electronics.

Major improvements to date to minimize electronics MLLW include

1. segregation of circuit boards; survey and release for recycling under DOE Order 5400.5; and

2. shipment of computers from RCAs to the Russian facility at Mayak for reuse.

3.4.5.1. Improvement Options

3.4.5.1.1. Minimize Electronics in RCAs. Establish a Laboratory/facility policy that RCAs should have only such electronics as are necessary to meet mission requirements. Cost: unknown. Funding source: undetermined. Waste avoided: unknown. ROI: unknown. Waste-reduction type: source avoidance.

3.4.5.1.2. Labwide RCA Electronics Reuse System. Once property-numbered equipment enters an RCA, it is marked as disposed of in the Laboratory property inventory system. In most cases when this equipment is no longer needed in the RCA, it still has considerable useful life. Under this reuse system, the Laboratory will establish a web-based database of known-to-be-uncontaminated equipment excessed from RCAs. Projects in other RCAs will be able to reuse this equipment. Cost: $50,000. Funding Source: WM Upstream Treatment Project. Waste avoided: unknown. ROI: unknown. Waste-reduction type: reuse. Implementation. A web page listing excess RCA electronics and other equipment will be established. The fraction of equipment reused will be measured to determine the waste avoided and thus the ROI.

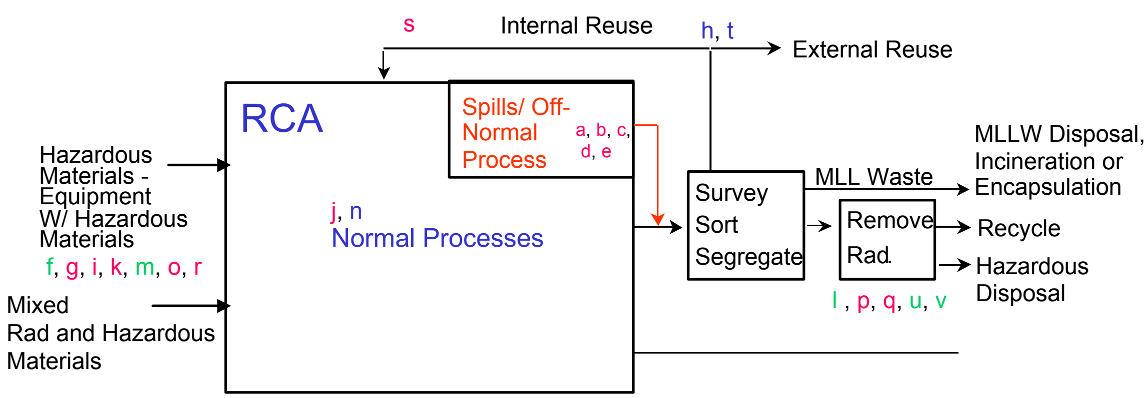
3.4.5.1.3. Russian/Kazakhstani Reuse of RCA Electronics. Similar to the system described for gloveboxes, excess electronics, for which there is no onsite reuse, will be transferred to Russian and Kazakhstani research facilities performing DOE-sponsored work. Cost: $60,000 (for shipping costs). Funding source: WM Upstream Treatment Project. Waste avoided: 120 m^3/year. ROI: 20,000%. (Note that the ROI is based on disposing of entire electronic instruments as MLLW—it is more likely that this equipment would be disassembled and surveyed and the circuit boards recycled at a lesser cost.)

Performance Measures

- Number of electronic components in the RCA (from the RCA inventory system).
- Age of RCA electronic components today and at the time of disposal.
- Volume of electronics disposed of per year.
- Volume of electronics reused per year.

3.4.6. Summary of Waste Minimization Options

Figure 3-10 shows project options in relation to the MLLW process map.



3.4.1 Spills
a. Mercury thermometer replacement, b. Nonhazardous spills, c. Further RCRA improvements, d. Inventory labeling, e. Further RCA size reduction
3.4.2 Gloveboxes
f. Substitute nonhazardous Materials, g. Design improvements, h. Russian reuse
3.4.3 Lead Shielding
i. Nonhazardous shielding, j. Protective coating for lead/cadmium, k. Optimize shielding design
3.4.4 Research Chemicals
l. Mediated electrochemical oxidation, m. Material substitution, n. Microchemistry, o. Oil-free pumps, p. Palladium Membrane Reactor, q. Hydrothermal processing
3.4.5 Electronic Equipment
r. Minimize electronics in RCAs, s. Labwide reuse, t. Russian reuse
Ongoing
u. Lead decontamination, v. Lead removal from gloveboxes

Fig. 3-10. Process map for MLLW minimization options.

4.0. LOW-LEVEL WASTE

4.1. Definition

LLW is defined in DOE Order 5820.2A (DOE, 1988) as waste that contains radioactivity and is not classified as high-level waste, TRU waste, spent nuclear fuel, or II(e)2 byproducts materials (for example, uranium or thorium mill tailings). Test specimens of fissionable material irradiated only for research and development and not for the production of power or plutonium may be classified as LLW, provided that the activity of TRU waste elements is <100 nCi/g of waste.

4.2. Waste System Description

Figure 4-1 depicts the process map for LLW generation at the Laboratory.

Materials, equipment, PPE, and contamination barriers (paper and plastic) are used in RCAs. After these items are no longer needed, they leave the RCA after being sorted, segregated, and, if possible, decontaminated. Some PPE, equipment, and tools are reused. Some equipment is sent off site for reuse. Compactable waste is sent to the TA-54, Area G, compactor for volume reduction before disposal. Much of the waste leaving RCAs is not radiologically contaminated and can be surveyed to determine if the waste meets the radiological release criteria. If so, then it is recycled or disposed of

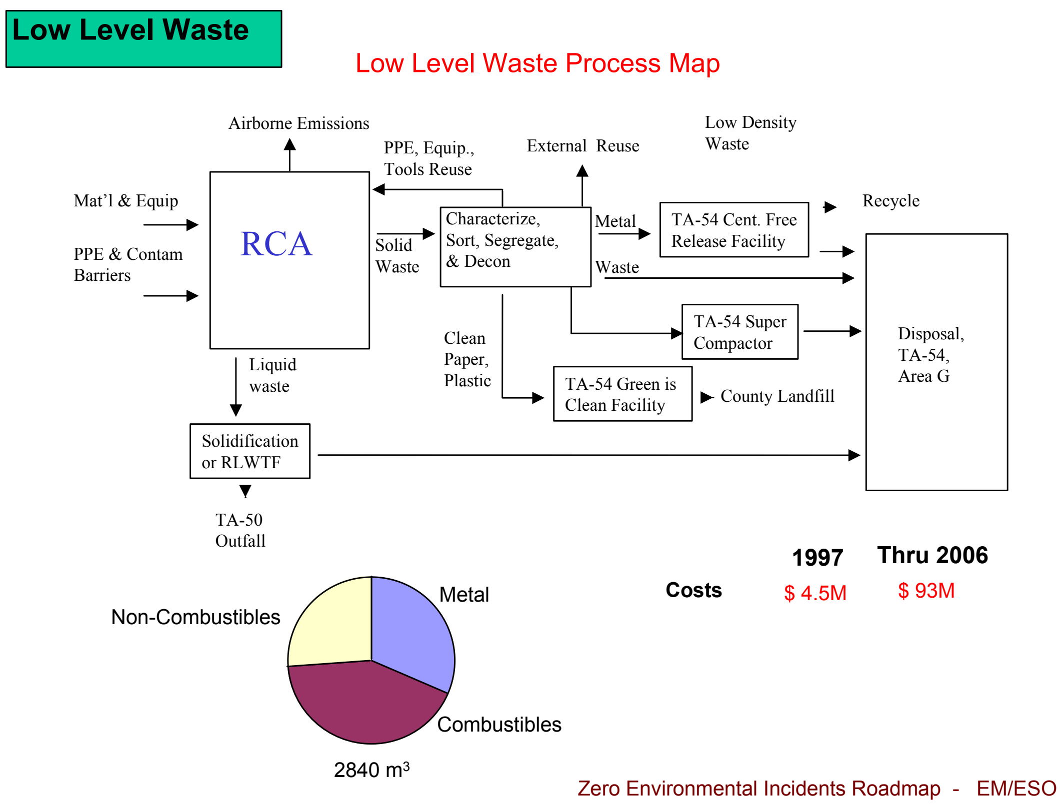


Fig. 4-1. Top-level LLW process map and waste streams.

as sanitary waste. Low-density waste is sent to the Green is Clean (GIC) Facility at TA-54, Area G, for verification that it meets the radiological release criteria. It then is sent to the County Landfill for disposal. Scrap metal items are sent to the Centralized Free Release Facility at TA-54, Area G, where the items are assayed to ensure that they meet the radiological release criteria and are recycled.

Solid LLW generated by the Laboratory's operating divisions is characterized and packaged for disposal at the onsite LLW disposal facility at TA-54, Area G. LLW minimization strategies are intended to reduce the environmental impacts associated with LLW operations and waste disposal by reducing the amount of LLW generated and/or minimizing the volume of LLW that will require storage or disposal on site. LLW minimization is driven by the requirements of DOE Order 5820.2A, the limited capacity of the onsite disposal facility, and other federal regulations and DOE Orders. A recent analysis of the LLW landfill at TA-54, Area G, indicates that at previously planned rates of disposal, the current disposal capacity would be exhausted in a few years. Reductions in LLW generation have extended this time; however, potentially large volumes of waste from planned construction upgrades could rapidly fill the remaining capacity. Construction of additional disposal sites depends on regulatory approval of and public acceptance of the SWEIS.

Liquid LLW typically is generated at the same facilities that generate solid LLW. It is transferred through a system of pipes and tanker trucks to the RLWTF at TA-50, Building 1. The radioactive components are removed and disposed of as solid LLW. The remaining liquid is discharged to a permitted outfall.

NMT, CST, Engineering Sciences and Applications (ESA), and EM divisions at the Laboratory produce the bulk of the LLW (see Fig. 4-2). NMT Division waste is produced from the production and maintenance of the nuclear weapons stockpile. CST Division waste is produced from a wide variety of Laboratory operations. ESA Division waste is produced from the manufacture of components for the nuclear weapons complex. EM Division waste is produced through the implementation of ER projects and from the operation of the TA-54, Area G, LLW disposal site. Unlike the other waste produced, waste produced from decommissioning and ER projects will be disposed of at the Envirocare site in Utah or in situ and is not addressed in this section.

The current cost for disposal of LLW at the Laboratory is $3668/m^3 for noncompactable waste and $734/m^3 for compactable waste. During 1993, a total of ~1140 m^3 of compactable and a total of 1700 m^3 of noncompactable LLW were disposed of at the Laboratory (not including ER waste). At today's disposal costs, these volumes would represent a total cost to the Laboratory of approximately $7 million/year. Fortunately, pollution prevention/waste minimization activities at the Laboratory have reduced the size of the waste stream substantially since 1993. Currently, the LLW disposal cost for the Laboratory is approximately $4.5 million/year.

The quantity of LLW generated at the Laboratory varies from year to year. The volume (in cubic meters) of non-ER, nonlegacy waste is shown in Fig. 4-3.

Figure 4-4 depicts the components making up the LLW stream at the Laboratory. Please note that waste produced from ER and decommissioning operations is not included in this figure.

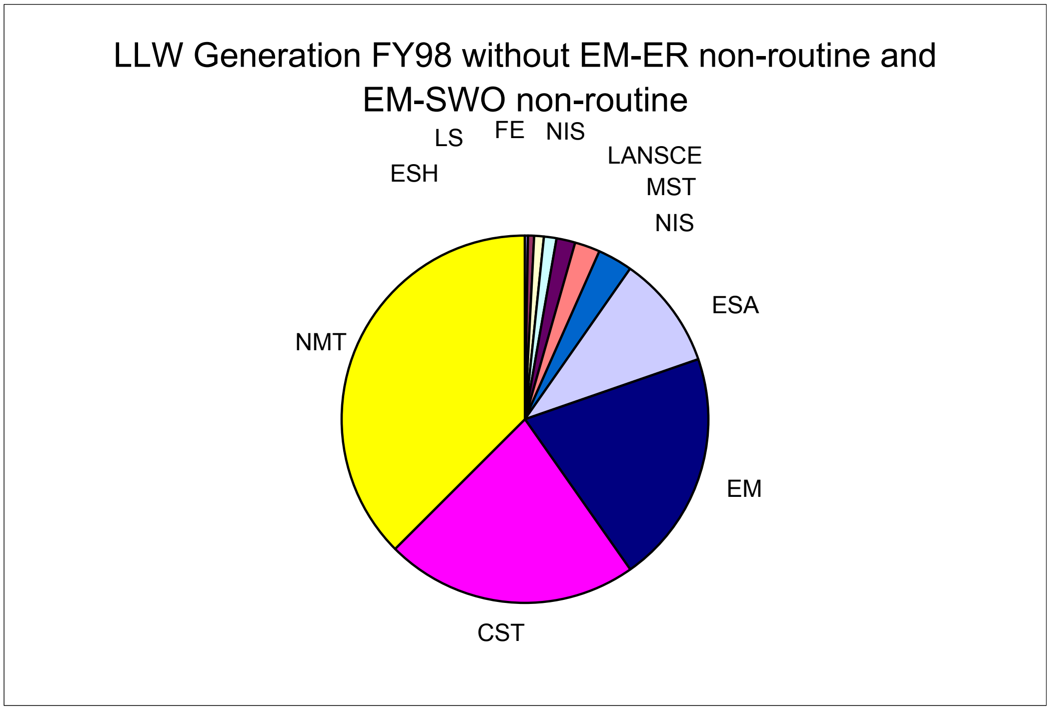


Fig. 4-2. LLW generation by Laboratory organization.

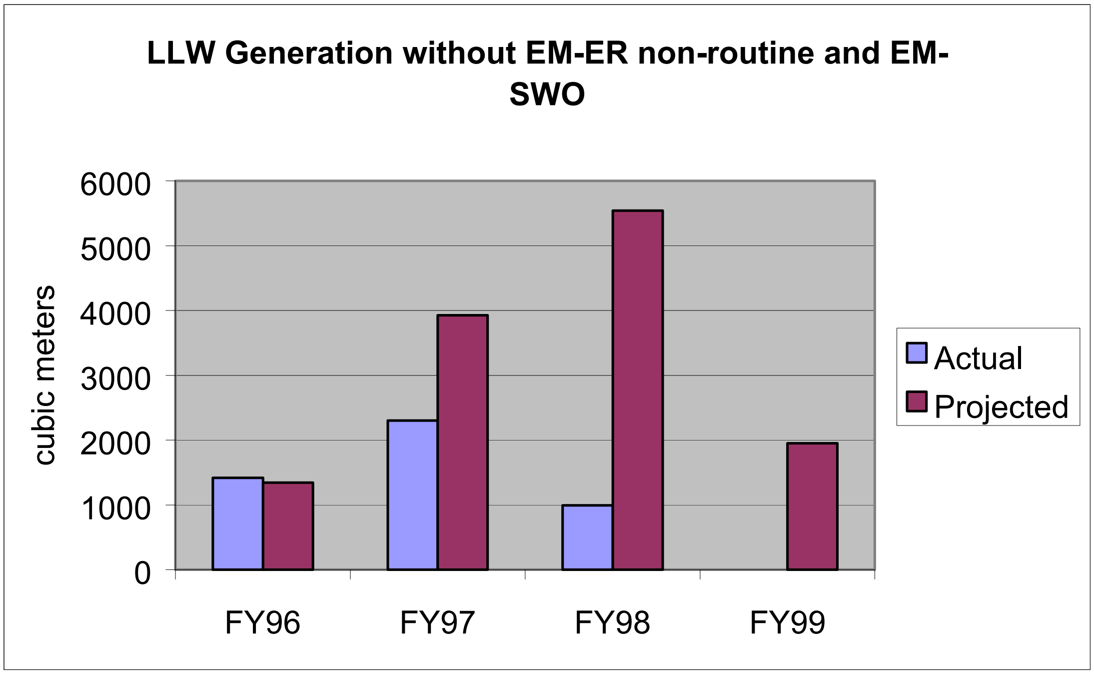


Fig. 4-3. LLW generation trend vs EM Ten Year Plan projections.

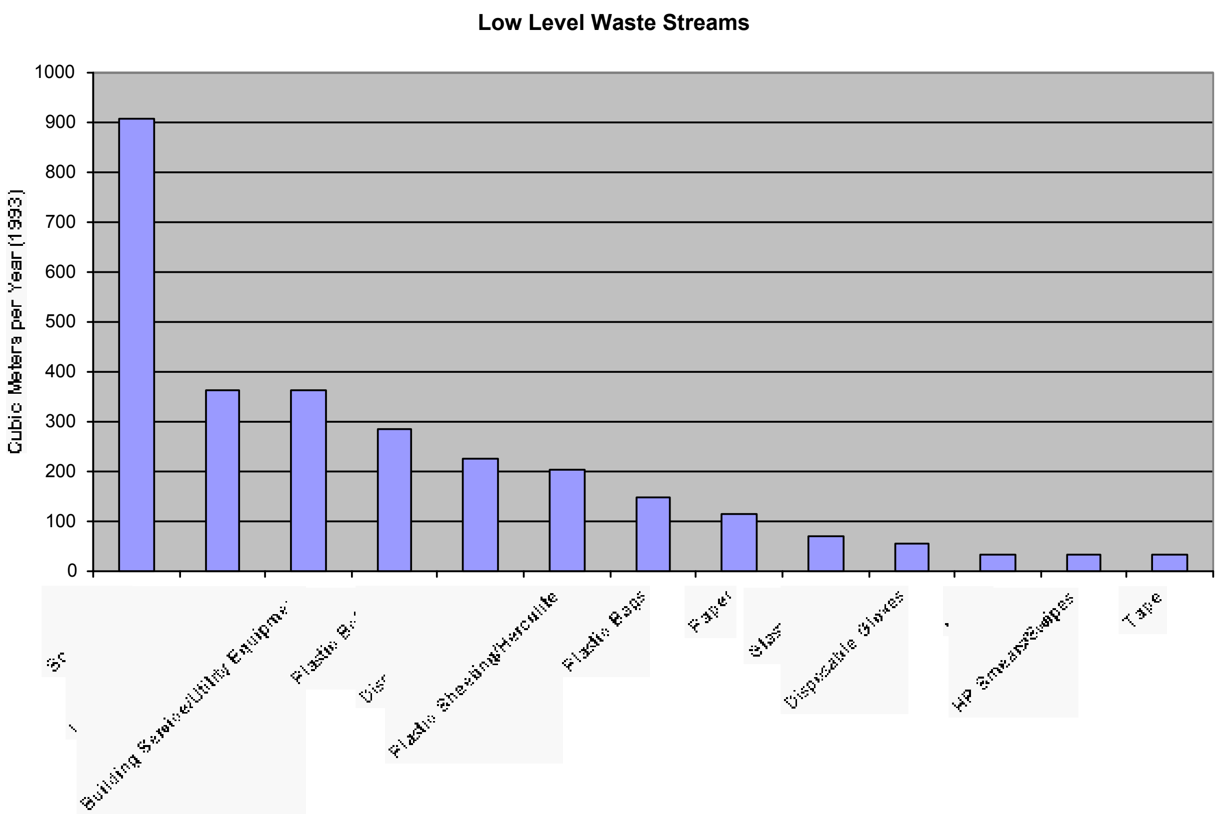


Fig. 4-4. LLW streams.

Plastic Bags (148 m^3): Plastic bags are used to package waste for disposal and to transport materials from one RCA to another.

Plastic Sheeting/Herculite (204 m^3): Plastic sheeting is used for contamination barriers. Plastic sheeting typically is placed on the floor areas or used to build containment structures around equipment to prevent the spread of radioactive contamination and to ease cleanup activities.

Plastic Bottles (284 m^3): Plastic bottles are used to contain aqueous samples and to move aqueous material from one RCA to another.

Disposable Wipes (227 m^3): Disposable wipes consist of any absorbent product (paper towels, wipes, cheese cloth, etc.) used as a cleaning aid or to absorb aqueous materials. The majority of these wipes are either used as a laboratory aid or contaminated during cleanup activities.

Paper (114 m^3): Office paper is used for recording data, working procedures, etc. Other forms of paper, such as brown paper wrapping material, are used as temporary contamination barriers to prevent the spread of contamination and to ease cleanup activities.

Wood (34 m^3): Wood is used as a construction material to erect temporary containment structures. Wood also is introduced into RCAs in the form of wooden pallets, scaffolding planks, and ladders. Wood also is used to support heavy objects being packaged for disposal to ensure that the objects do not shift in their packaging container during transport.

HP Smears/Swipes (34 m^3): This material consists of filter paper material and large "masslin" swipes used to monitor removable contamination levels within RCAs.

Tape (34 m^3): Tape is used for a variety of purposes within RCAs. Tape is used as an aid to seal PPE. It is also used to fix plastic and paper contamination barriers in place.

Disposable Gloves (57 m^3): Disposable gloves are an essential PPE requirement when working in RCAs. Disposable gloves offer a high level of dexterity. If more protection is required, a heavier, launderable pair of gloves is worn over the disposable gloves.

Glassware (71 m^3): This waste stream consists of laboratory glassware that can no longer be used because it cannot be cleaned well enough to prevent the cross contamination of samples.

Laboratory Equipment (362 m^3): This waste stream consists of a variety of laboratory equipment that is either outdated, no longer functional, or for which a use cannot be found. This waste stream consists of hot plates, furnaces, centrifuges, computers, and a variety of miscellaneous analytical instrumentation.

Building Service/Utility Equipment (362 m^3): This waste stream consists of a variety of equipment used to provide basic facility services, such as pumps, ventilation units, and compressors. This equipment generally is removed during facility maintenance or upgrade activities.

Scrap Metal (909 m^3): This waste stream consists of a large variety of items, including steel lab/office furniture, miscellaneous sheet metal objects (ventilation ducts, etc.), structural steel, piping, and gloveboxes. Typically, the majority of this material is produced during facility upgrade activities.

4.3. Issues and Constraints

4.3.1. LLW Disposal Capacity

The LLW disposal site at TA-54, Area G, has a limited capacity. An environmental assessment is in progress that will allow expansion of the current disposal site. If the environmental assessment is not approved, the disposal capacity will be expended within the next few years. Offsite disposal of LLW will increase waste costs significantly. By reducing the LLW stream to 500 m^3/yr, the current disposal capacity can be extended to last another 25 to 50 years.

4.3.2. Release Criteria

Every waste item leaving an RCA is assumed to be radiologically contaminated unless

1. there is acceptable proof that the item was never radiologically contaminated and

2. radiological surveys indicate that the item meets the criteria specified in DOE Order 5400.5.

Unfortunately, the criterion specified in DOE Order 5400.5 applies only to surface-contaminated objects. There are no criteria specified for porous or activated objects that may be volume contaminated, e.g., wood planks. In addition, many surface-contaminated objects cannot be surveyed because many of the surfaces are inaccessible to the available survey instrumentation and must be treated as volume contaminated. DOE Order 5400.5 allows the case-by-case establishment of volume contamination criteria. However, because of the lengthy timeframes required to acquire State regulatory approval, the establishment of criteria on a case-by-case basis is not practicable. The ANSI has proposed a new standard (ANSI N13.12) that would establish volume contamination limits. DOE and State acceptance of this standard would avoid the disposal of substantial amounts of LLW that currently are being disposed of because no regulatory criteria exist to classify them as non-LLW.

4.4. Waste Streams

The waste streams defined in Section 4.2 arise from processes at various Laboratory sites and in some cases are interrelated. For example, much of the Laboratory equipment (computers, etc.) contains circuit boards that must be disposed of as MLLW. The goal for the TRU waste program is to decontaminate TRU waste gloveboxes to LLW levels. The goal for the LLW program is to release as much waste as possible for sanitary waste disposal. These interrelationships are not necessarily shown on the process maps for LLW but are shown on the process maps for the other waste streams.

The waste-stream analyses are organized into the following three areas utilizing process maps:

1. a waste-stream description, including a summary of recent waste minimization successes;

2. waste-stream reduction options; and

3. waste-stream performance measures, objectives, and time frames. (Note: Waste-stream performance objectives and time frames are not included in this version of the process map.)

The waste-stream reduction options include (1) procedural changes requiring no funding, (2) funded projects, (3) well-defined projects without funding, and (4) waste-reduction concepts that require further definition. The LLW stream has been broken down into three major categories: combustible waste, noncombustible waste, and scrap metal. Options not identified for these categories are identified in the general process map for the overall waste stream.

4.4.1. General

Materials, equipment, air, and water are brought into RCAs where work is performed. These items are radiologically contaminated and then leave the facility in the form of air emissions, solid LLW, or aqueous LLW. Approximately 50% of the solid LLW leaving the RCAs is not contaminated but must be disposed of as LLW because no regulatory standard currently exists to release material for disposal as sanitary waste. Many general improvement options are obvious and do not require any additional breakdown of the waste stream to be identified. These options are listed in the following sections. Additional options for the solid waste streams are listed in a further breakdown of the waste stream under the categories of combustible, noncombustible, and scrap metal waste.

4.4.1.1. Improvement Options

4.4.1.1.1. DOE Adoption of ANSI N13.12. This option is discussed in detail in Section 4.3.2. Adoption of this standard will allow the release of ~50% of the LLW stream to the County Landfill for disposal. Waste-avoidance type: segregation.

4.4.1.1.2. DX Confined Testing. Currently, DX Division conducts tests utilizing depleted uranium (DU). The testing is performed in the open environment, and the DU contaminates the surrounding environment through airborne emissions. This option would identify confined methods of testing to eliminate these emissions. This option currently is unfunded. Waste-avoidance type: source reduction.

4.4.1.1.3. Plasma Melter or Oxidation of DU. Currently, the machining of DU creates DU chips and turnings that are pyrophoric. To dispose of this waste stream, the waste must be solidified. Solidification results in the creation of ~20 m^3 of LLW annually. Three options currently exist to reduce this waste stream: incineration at an offsite facility, oxidation and disposal at the Laboratory, plasma melting of the DU chips, and turning and recycling of the melted product. The current plan is to send this waste off site for incineration. Plasma melting would completely eliminate this waste stream. Oxidation would decrease the current costs associated with incineration. Clearly, plasma melting is the preferred option. This option currently is unfunded. Waste-avoidance type: internal recycle.

4.4.1.1.4. Construction Waste Minimization. This option would modify existing and future construction contracts to include waste minimization. Implementation of this option will ensure that waste generated during construction or upgrade projects is minimized. This option is being funded by the Environmental Stewardship program. Waste-avoidance type: segregation, external recycle/reuse, volume reduction, treatment.

4.4.1.1.5. Asphalt and Concrete Crusher. During the decommissioning of facilities at the Laboratory, a large amount of asphalt and concrete debris is generated. The purchase and operation of a crusher will enable this material to be buried in place or reused, which would provide additional valuable disposal capacity at the TA-54, Area G disposal facility. This project has been funded, and an air permit application has been filed with the NMED. Waste-avoidance type: internal recycle.

General waste minimization actions taken to date include the following.

1. Minimize material brought into RCAs by unpacking all items before transferring them into an RCA. By eliminating a requirement to unpack all materials before transferring them into RCAs, it is estimated that the LLW stream was reduced by several hundred cubic meters per year.

2. Reduce RCA floor space. By eliminating ~150,000 ft^2 of RCA floor space at the Laboratory, it is estimated that the LLW stream was reduced by 340 m^3/yr.

3. Use of Launderable PPE. By using launderable PPE, the Laboratory has virtually eliminated the use of disposable PPE and the waste volume associated with its disposal.

4. Modification of the RLWTF. Improvements at this facility for the treatment of the aqueous waste stream are estimated to reduce the solid waste disposed of by 50 m^3/yr.

5. An asphalt/concrete crusher has been purchased and currently is being used by the decommissioning organization to reduce the volume of concrete debris. A reuse pathway for asphalt has not yet been developed.

4.4.2. Combustibles

Combustible materials make up ~40% of the total LLW produced at the Laboratory annually. Combustible items include

- plastic bags,
- plastic sheeting/Herculite,
- plastic bottles,
- disposable wipes,
- paper,
- wood,

- HP smears/swipes,
- tape, and
- disposable gloves.

The use of these materials at the Laboratory is depicted in the Fig. 4-5.

To accomplish programmatic work, these combustibles are brought into RCAs. After the materials are used, they leave the RCA as LLW. For waste that acceptable knowledge indicates is not contaminated, this waste is segregated, verified clean, and disposed of at the Sanitary Landfill. The remaining waste is segregated into compactable and noncompactable waste. Compactable waste is sent to the TA-54, Area G, compactor for volume reduction, approximately a one-to-five compaction, and then disposed of as LLW. The remaining waste stream is sent directly to disposal. A further breakdown of this waste stream is depicted in Fig. 4-6.

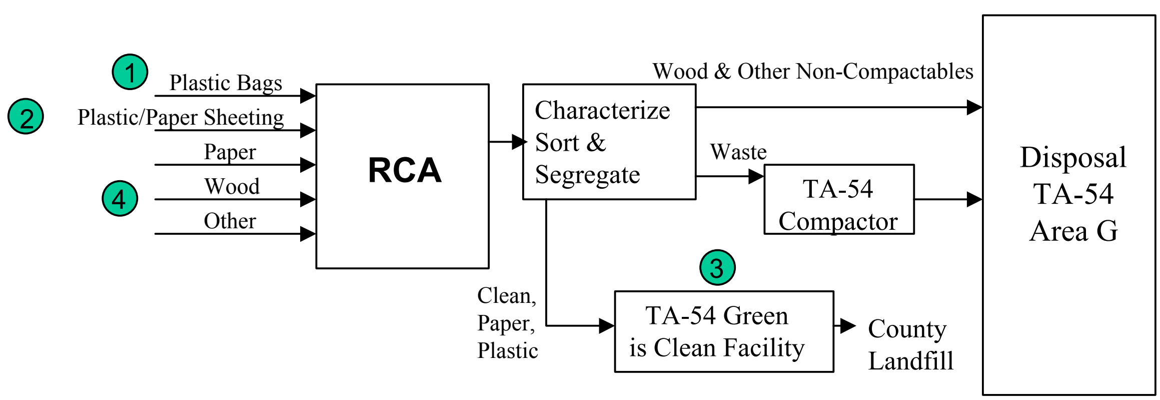


Fig. 4-5. Combustible waste stream. Numbers refer to the last digit of the improvement option title.

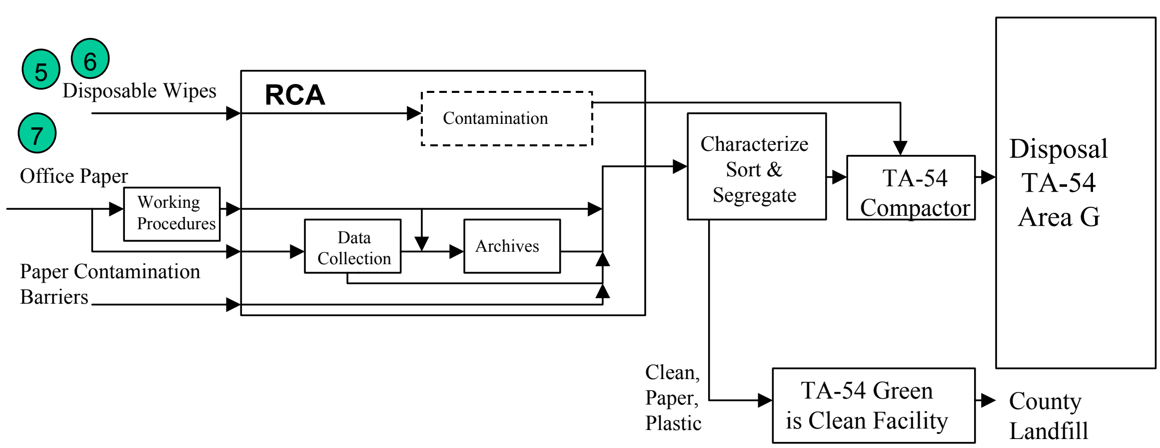


Fig. 4-6. Compactable waste stream. Numbers refer to the last digit of the improvement option title.

Paper enters RCAs in the form of three major material categories: disposable wipes, office paper, and contamination barriers. Office paper is used for data collection and the transmission of working procedures. After these activities are performed, the data or procedures often are archived for a period of time before disposal. Typically, acceptable knowledge can be used to declare office paper "clean," and it can be sent to the TA-54 GIC Facility for verification and disposed of at the County Landfill. However, for office paper that has been archived, the maintenance of the acceptable knowledge necessary to declare the paper "clean" is more difficult. Paper contamination barriers, generally in the form of brown wrapping paper, enter an RCA to provide a temporary contamination barrier and then are removed and disposed of. Disposable wipes are used as both a laboratory and a cleaning aid. The disposable wipes usually become contaminated and must be disposed of as LLW.

4.4.2.1. Improvement Options. Two major options are possible to minimize this waste stream: (1) material substitution and (2) an increase in the amount of material that can be segregated as "clean," verified as "clean" at the GIC facility, and disposed of at the County Landfill. The following subtopics list the improvement options currently identified for this waste stream.

4.4.2.1.1. Substitute Launderable Bags for Plastic Bags. Plastic bags often are used to transport materials from one RCA to another. This option would replace the use of plastic bags with launderable bags. There is no cost associated with this change. A laundry contract is already in place with a vendor to supply launderable materials to the Laboratory. Waste-avoidance type: material substitution and internal recycle.

4.4.2.1.2. Substitute Launderable Contamination Barriers for Plastic Sheeting and Paper. Plastic sheeting and paper often are used to provide contamination barriers inside of RCAs. This option would replace the use of these materials with launderable barriers (cloth tarps, etc.). A laundry contract is already in place with a vendor to supply launderable materials to the Laboratory. However, sufficient contamination barrier options currently are not available. Through Environmental Stewardship Program funding, a wider selection of contamination barriers will be identified and added to the materials currently available through the existing laundry contract. It is estimated that this waste stream contributes up to 200 m^3/yr of waste to the LLW stream. Waste-avoidance type: material substitution and internal recycle.

4.4.2.1.3. Increase the Amount of Paper/Plastic Sent to the GIC Facility through the Adoption of ANSI 13.12. The need for this option has already been discussed in Section 4.3.2. The effort to adopt this standard will be funded through the Environmental Stewardship Program. It is estimated that 50% of the combustible waste stream could be avoided through the adoption of this or a similar standard. Waste-avoidance type: segregation.

4.4.2.1.4. Substitute the Use of Metal Pallets, Ladders, and Construction Materials for Wood. This option would eliminate the use of wood within RCAs, except to package LLW safely for transport. Metal objects easily can be surveyed for radiological contamination and then reused or recycled. This option is funded through the Environmental Stewardship Program. It is estimated that the implementation of this option will reduce the LLW stream by 34 m^3/yr. Waste-avoidance type: material substitution.

4.4.2.1.5. Utilize Air-Dry Dishwashing Systems for Laboratory Glassware Whenever Possible to Minimize the Need for Disposable Wipes. This option would eliminate the use of disposable wipes to dry laboratory glassware. The disposal of disposable wipes makes up ~8% of the LLW stream. The exact impact on the LLW stream currently is unknown, and this option is not funded. However, through the Environmental Stewardship Program, generators will be encouraged to use dishwashing systems whenever possible. Waste-avoidance type: source reduction.

4.4.2.1.6. Utilize Launderable Rags Whenever Possible. This option will replace the use of disposable wipes with launderable rags for maintenance or other activities where this substitution is possible. Because of potential cross contamination, launderable rags cannot be used in most laboratory operations. There is no cost associated with this option. A laundry contract is already in place, and launderable rags are available through this contract. The use of disposable wipes accounts for ~8% of the material in the LLW stream. It is estimated that the substitution of launderable rags may reduce this waste stream by 50%. Waste-avoidance type: material substitution and internal recycle.

4.4.2.1.7. Utilize Electronic Data Techniques Whenever Possible for Working Procedures and Data Collection. This option would replace the use of office paper to transmit working procedures and data collection whenever possible. It is estimated that implementation of this option could reduce the amount of office paper used by at least 50%. This option currently is unfunded. However, an effort to increase the use of electronic data techniques will be supported through the Environmental Stewardship Program. Implementation of this option will require identifying issues that surround the need to record signatures on important documentation and to find better viewing systems for documentation (systems that allow for handwritten notes, etc.). Waste-avoidance type: source reduction.

Combustible waste minimization actions taken to date include the following.

- Launderable PPE has been substituted for disposable PPE in most cases.
- A GIC facility has been established to verify that combustibles are “clean” and can be sent to the County Landfill. This facility currently avoids the disposal of ~100 m^3/yr of LLW.

- A compaction facility has been established at TA-54 to reduce the waste volume of the compactable fraction of the combustible waste stream. It is estimated that this facility will reduce the volume of the combustible waste stream by 80%. At current waste generation rates, it is estimated that this will reduce this waste stream by ~300 m^3/yr.

Performance Measures

1. Track the amount of launderable materials used at the Laboratory.

2. Track the TA-54 waste verification results to ensure that compactable waste is being segregated from noncompactable waste.

3. Track the volume of wood products used in RCAs.

4. Track the amount of material processed through the GIC facility.

4.4.3. Noncombustibles

Noncombustible materials make up ~28% of the total LLW produced at the Laboratory annually. Noncombustibles include

- glassware,
- laboratory equipment,
- building service/utilities equipment, and
- tools.

The use of these materials at the Laboratory is depicted in Fig. 4-7. To accomplish programmatic work, these materials are brought into RCAs. After the materials are used, they leave the RCAs as LLW. For materials that acceptable knowledge indicates is not contaminated, this material is segregated, reused internally, sent off site for reuse, or recycled. Materials that are contaminated or for which acceptable knowledge does not exist are decontaminated and recycled, reused, or disposed of as LLW. A further breakdown of this waste stream is depicted in Fig. 4-8.

4.4.3.1. Improvement Options. Because the majority of these materials are critical to programmatic activities, it is difficult to utilize source-reduction techniques to eliminate their use. However, the amount of material entering an RCA definitely can be minimized. The following lists the improvement options currently identified for this waste stream.

4.4.3.1.1. Whenever Possible, Use Protective Coatings and/or Other Contamination Barriers to Ensure That Equipment Is Not Contaminated. This option attempts to ensure that materials entering an RCA can leave the RCA as clean and be reused or recycled. Implementation of this option requires the identification and use of contamination barriers, such as environmental cabinets for computers and strippable coatings for other equipment. This option currently is not funded.

4.4.3.1.2. Develop Improved Characterization Techniques to Increase the Amount of Material That Can Be Recycled. TRU radioisotope contamination is very difficult to detect because of the small range of alpha particles in the air. New characterization techniques are needed to enhance the ability to detect alpha particles so that the amount of equipment that can be reused or recycled can be increased. This option currently is not funded. Waste-avoidance type: external recycle.

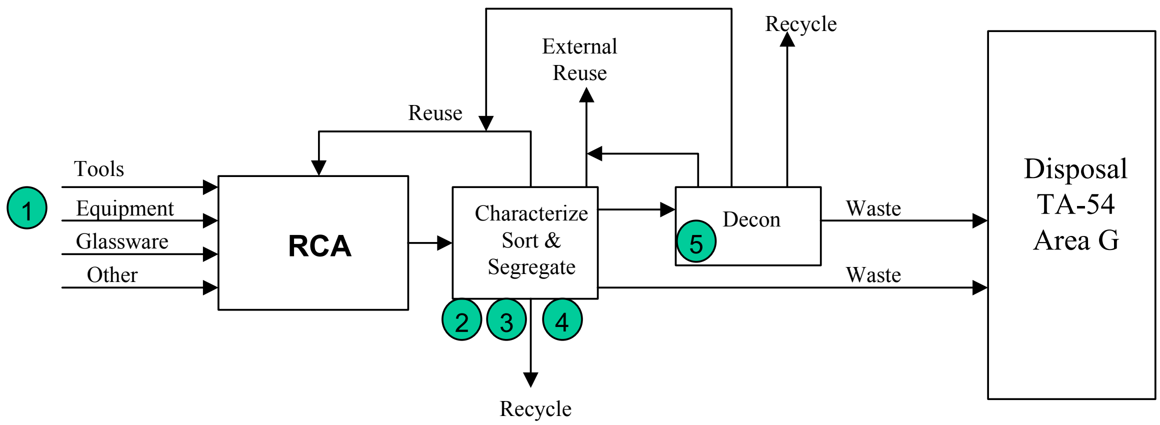


Fig. 4-7. Noncombustible waste stream. Numbers refer to the last digit of the improvement option title.

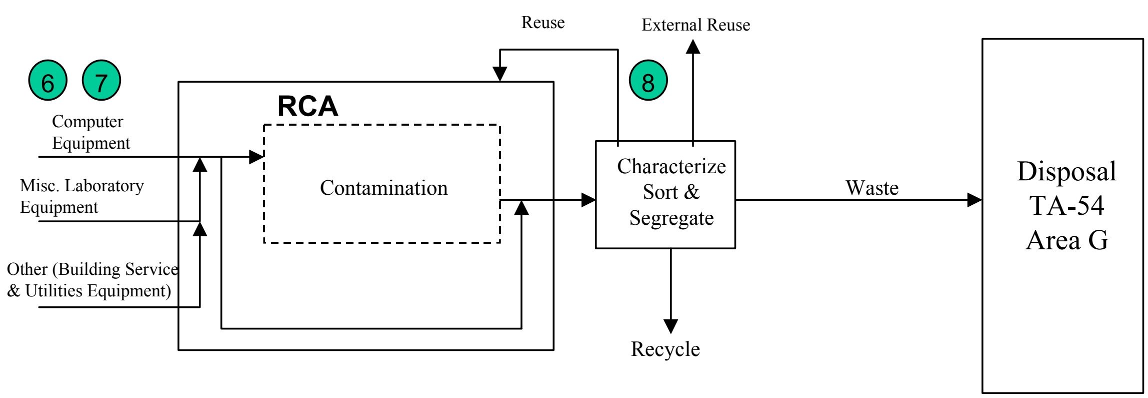


Fig. 4-8. Noncombustible waste stream.

4.4.3.1.3. Adopt ANSI N13.12 to Establish Volume Contamination Criteria and to Ease the Characterization Process. As previously discussed, adoption of this standard would increase the amount of material that could be reused or recycled substantially. Waste-avoidance type: segregation.

4.4.3.1.4. Fund a Project to Characterize/Sort/Segregate/Decontaminate Equipment in FY99. Establish a Recharge Rate in FY00. As depicted in Fig. 4-7, this activity is essential to minimize LLW generation. A project has been funded for FY99 to implement this option and is expected to avoid the disposal of 70 m^3 in FY99. Waste-avoidance type: segregation, external recycle, treatment.

4.4.3.1.5. Develop Improved Decontamination Capabilities for Tools and Equipment. It is estimated that ~50% of the equipment leaving RCAs is contaminated and requires decontamination before the equipment can be reused or recycled. Currently, only manual decontamination techniques are available to decontaminate this equipment. Therefore, only a small fraction of the equipment that could be decontaminated currently is being reused or recycled. This project currently is unfunded. Waste-avoidance type: internal recycle.

4.4.3.1.6. Minimize Contamination Areas and Improve Acceptable Knowledge to Minimize the Amount of Equipment That Becomes Contaminated and to Simplify the Characterization Process. Through better work techniques, contamination areas can be minimized to decrease the probability that equipment can become contaminated. Efforts currently are underway to identify methods to improve acceptable knowledge. It is difficult to maintain acceptable knowledge on equipment that has been inside of an RCA for extended periods of time. By placing some type of device inside each piece of equipment that can monitor the contamination potential internally, it may be possible to determine easily whether the equipment is internally contaminated and whether it can be reused or recycled. This effort currently is funded through the Environmental Stewardship Program. Waste-avoidance type: source reduction.

4.4.3.1.7. Set Up a System for Using the Property Accounting System to Ensure That the Need and Alternatives Are Fully Evaluated before Equipment Is Utilized in RCAs. This option will use the property management system to ensure that only necessary equipment is brought into RCAs and that equipment that is necessary to bring into an RCA is evaluated properly to determine what methods could be used to prevent its contamination. This option currently is funded through the Environmental Stewardship Program. Waste-avoidance type: source reduction.

4.4.3.1.8. Establish an Internal and External Database System to Encourage the Reuse of Equipment. Encourage the reconditioning of equipment to enhance reuse rates. Much equipment currently being disposed of can be reused internally or sent off site for reuse. In addition, much equipment currently being disposed of can be reconditioned and then reused. This option will establish a database to identify this equipment and provide an easily accessible resource to individuals or organizations that may need this equipment. This option currently is funded through the Environmental Stewardship Program. Waste-avoidance type: internal recycle.

Noncombustible waste minimization actions taken to date include the following.

1. A total of 3 m^3 of equipment has been sent to the Russian nuclear industry for reuse and another 35 m^3 has been identified for reuse by the Russian nuclear industry.

2. Approximately 35 m^3 of equipment has been assembled for sort/segregation/ decontamination activities that will result in a large fraction of this equipment being recycled.

3. An internal database for the Laboratory has been established to identify equipment for reuse.

Performance Measures

- Issue a report detailing improved decontamination techniques. Develop funding mechanisms for the new techniques.

- Fund a characterization/sort/segregation/decontamination project in FY99. Establish a recharge rate for FY00.

- Utilize the property accounting system to track equipment entering RCAs.

- Track reuse databases to ensure that excess equipment is being utilized.

4.4.4. Scrap Metal

This waste stream consists of structural steel, sheet metal objects, lab furniture, and other scrap metal items that can be recycled. Many of the options available for this waste are similar to those already identified for equipment, with the exception of reuse. A process map for this waste stream is depicted in Fig. 4-9.

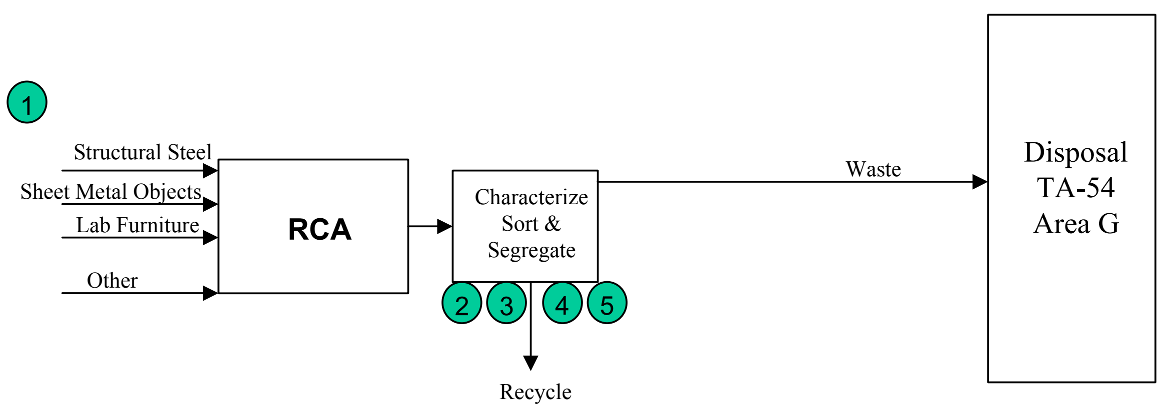


Fig. 4-9. Scrap metal waste stream. Numbers refer to the last digit of the improvement option title.

4.4.4.1. Improvement Options. As mentioned, many of the improvement options for this waste stream are similar to those already discussed for the other waste streams. These options are the adoption of ANSI N13.12: improved characterization techniques; the use of protective coatings or contamination barriers; the development of decontamination techniques; and the funding of characterization, sorting, and segregation activities in FY99. Therefore, these options will not be discussed again in this section.

Scrap metal waste minimization actions taken to date include the following.

- An extensive program to encourage the characterization, sorting, segregation, and recycling of scrap metal at the Laboratory has been in place for several years. During this time, a total of 2800 m^3 of scrap metal has been recycled.

- To identify a decontamination option for this process map, a sponge-jet decontamination system was piloted at the Laboratory; a total of 105 m^3 of LLW disposal volume was avoided and 15 m^3 of scrap metal was recycled.

- To assist the waste generators and encourage recycling, a centralized facility has been established at TA-54, Area G, to recycle scrap metal. Also, a recharge rate has been established. This facility recycled a total of 120 m^3 of scrap metal in FY98.

Performance Measures

Track the quantity of scrap metal recycled.

4.4.5. Summary of Waste Minimization Options

Figure 4-10 summarizes the majority of waste minimization options discussed in this section.

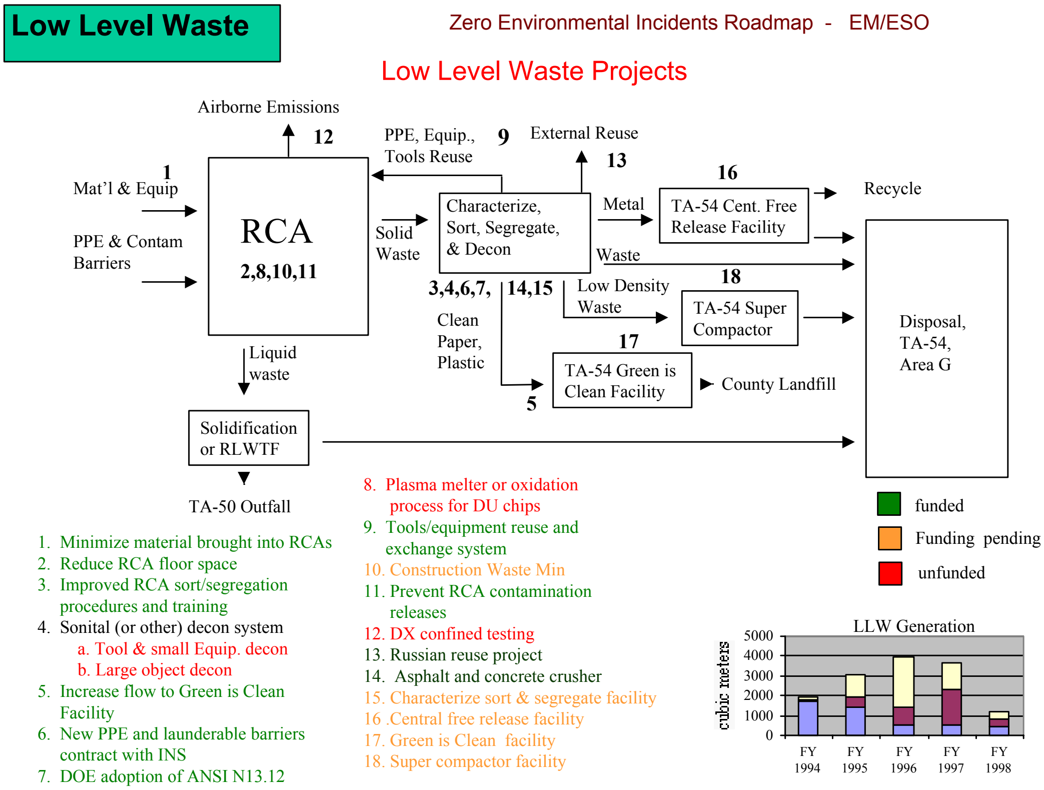


Fig. 4-10. Summary of LLW waste minimization options.

5.0. HAZARDOUS WASTE

5.1. Definition

Hazardous waste (RCRA EPA, 1976) and 40 Code of Federal Regulations (CFR) 261.3 (EPA, 1989), as adopted by the NMED, is any solid waste that

1. is generally hazardous if not specifically excluded from regulation as a hazardous waste;

2. is listed in the regulations as a hazardous waste;

3. exhibits any of the defined characteristics of hazardous waste (i.e., ignitability, corrosivity, reactivity, or toxicity); or

4. is a mixture of solid and hazardous waste.

The Laboratory produces routine and nonroutine hazardous waste as a byproduct of mission operations. Hazardous waste also includes substances regulated under the Toxic Substances Control Act (TSCA), such as polychlorinated biphenyls (PCBs) and asbestos. Finally, a material is hazardous if it is regulated as a Special Waste by the State of New Mexico as required by the New Mexico Solid Waste Act of 1990 (State of New Mexico, 1990) and defined by the most recent New Mexico Solid Waste Management Regulations, 20NMAC 9.1 (NMED, 1994) or current revisions.

Hazardous wastes are disposed of through two Laboratory subcontractors: Safety-Kleen (TG), Inc., and Chemical Waste Management, Inc. They send waste to permitted treatment, storage, and disposal facilities (TSDFs), recyclers, energy recovery facilities for fuel blending or burning for British thermal unit recovery, or other licensed vendors (as in the case of mercury recovery). The treatment and disposal fees are charged back to the Laboratory at commercial rates specific to the treatment and disposal circumstance. The actual cost varies with the circumstances; however, the average cost for onsite waste handling by SWO and offsite disposal is $13.75/kg.

5.2. Waste System Description

Most Laboratory activities generate some amount of hazardous waste. Hazardous waste commonly generated at the Laboratory includes many types of laboratory research chemicals, solvents, acids, bases, carcinogens, compressed gases, metals, and other solid waste contaminated with hazardous waste. This may include equipment, containers, structures, and other items intended for disposal and contaminated with hazardous waste (e.g., compressed gas cylinders).

A comparison of the actual quantity of hazardous waste (in kilograms) generated at the Laboratory and future waste projections for hazardous waste are shown in Fig. 5-1, excluding the waste generated by EM-ER, asphalt from EM-SWO, and wastewater from the Fenton Hill project. The actual generation is somewhat overstated because much of the material shown as waste actually was recycled after it was

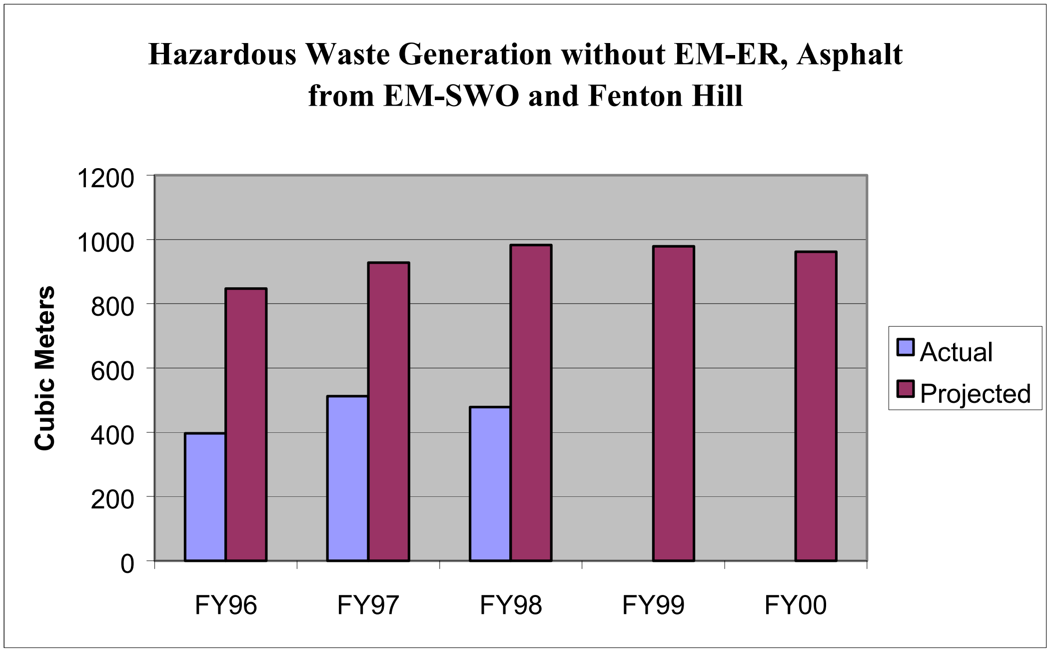


Fig. 5-1. Hazardous waste generation and projected generation.

classified as waste. However, the current waste accounting methods do not remove material from the waste manifest when it is recycled.

Various hazardous materials are already in the Laboratory's material inventory or are brought in as part of Laboratory operations. These substances are used in performing work and are collected when they are depleted or no longer needed. They are then collected, sorted, and segregated. Some materials are reused within the Laboratory, and others are decontaminated for reuse. Those materials that cannot be decontaminated or recycled are sent off site for disposal. The cost of handling and disposing of hazardous waste is $12.75/kg.

Hazardous waste generation, excluding EM-SWO asphalt waste and Fenton Hill and EM-ER nonroutine waste, decreased from 507 tonnes in FY97 to 478 tonnes in FY98. This success is due to a variety of process modifications and recycling efforts.

Hazardous waste is projected to cost an average of $12.75/kg in FY99. EM-SWO will spend a total of $6,182,000 managing newly generated hazardous waste in FY99. Over FY97 and FY98, the hazardous waste volume has been dominated by nonroutine waste. In addition to categorizing waste as routine and nonroutine, hazardous waste also is tracked according to the way it is regulated; that is, RCRA, State, or TSCA waste. The relative magnitude of the waste types (in kilograms) is shown in Fig. 5-2 for hazardous waste generation, with exclusions noted.

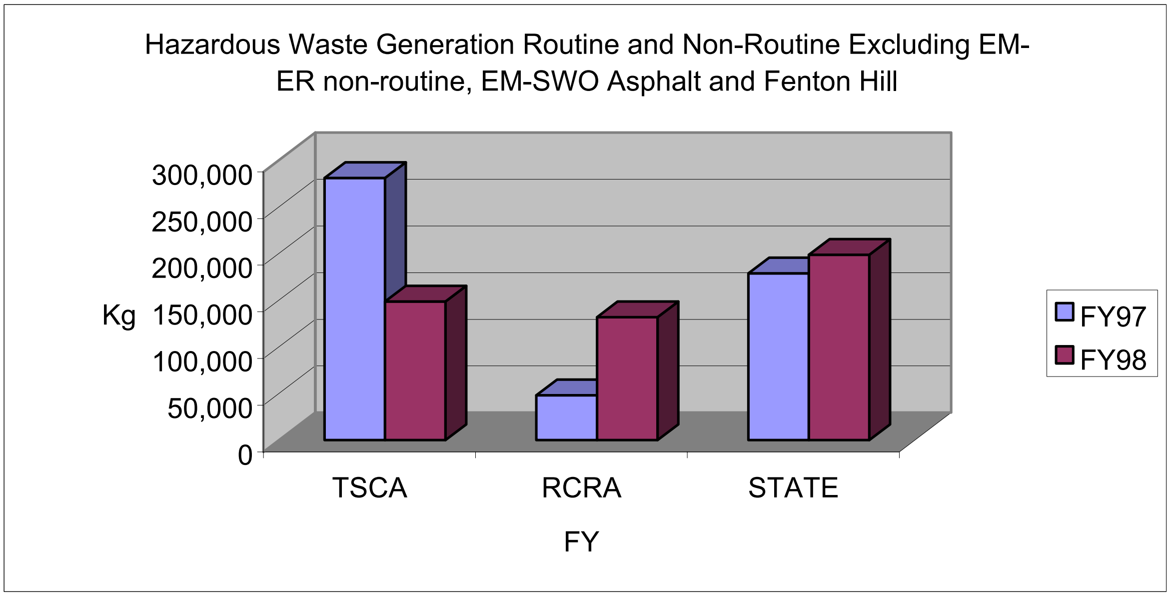


Fig. 5-2. Hazardous waste generation.

The top-level process map for hazardous waste is shown in Fig. 5-3. Upon generation, hazardous waste typically is transferred to a 90-day storage area. Otherwise, upon receipt of proper waste and Department of Transportation documentation, hazardous waste is transferred to SWO (Area L, TA-54) for storage, bulking, and transportation. From Area L, it is sent to commercial disposal facilities.

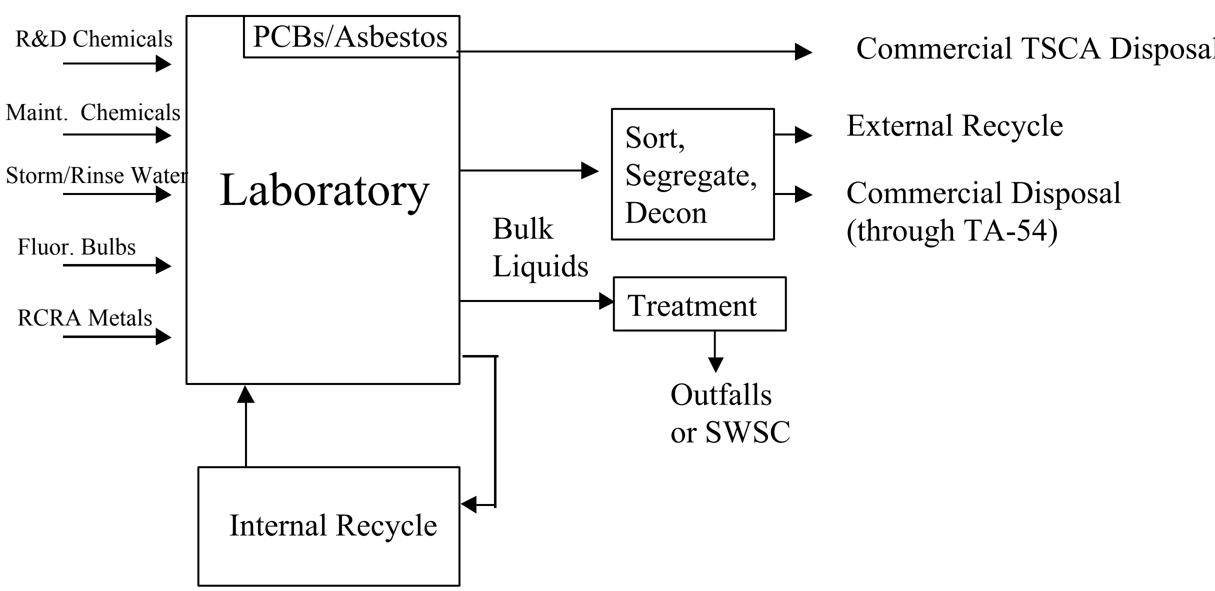


Fig 5-3. Hazardous waste roadmap.

5.3. RCRA Waste Breakdown

Approximately 56 tonnes of RCRA waste was generated in FY98. The pie chart in Fig. 5-4a represents a breakdown of this waste stream. Eighty percent of the wastestreams will be described following the figure. The asterisked items on this and subsequent charts denote materials that are carried as waste in the databases but in fact are recycled.

Fluorescent Bulbs* (11.6 tonnes): Fluorescent bulbs are used across the Laboratory complex. JCNNM performs most bulb changeouts. Most of the bulbs are recycled.

Garnet Sand* (8.1 tonnes): This abrasive is used by JCNNM shops to machine large lead and steel plates for NMT Division. The abrasive is contaminated with lead and recycled to recover the lead content.

Chemical Solutions (6.1 tonnes): Spent chemicals and chemical solutions are generated by Laboratory production, maintenance, and R&D operations. A fraction of the chemical wastes is expired, unused chemicals.

Petroleum and Oils (5.0 tonnes): Several Laboratory processes produce RCRA-contaminated, petroleum, and oil-based wastes.

Waters (4.5 tonnes): Various rinse waters are contaminated with RCRA constituents. A variety of RCRA components in dilute solutions also are used at the Laboratory.

Chiller Cleaner* (3.3 tonnes): Chiller cleaner is a solution used to remove scaling from heat exchangers. Chiller cleaning usually is performed by JCNNM. Chiller cleaners are

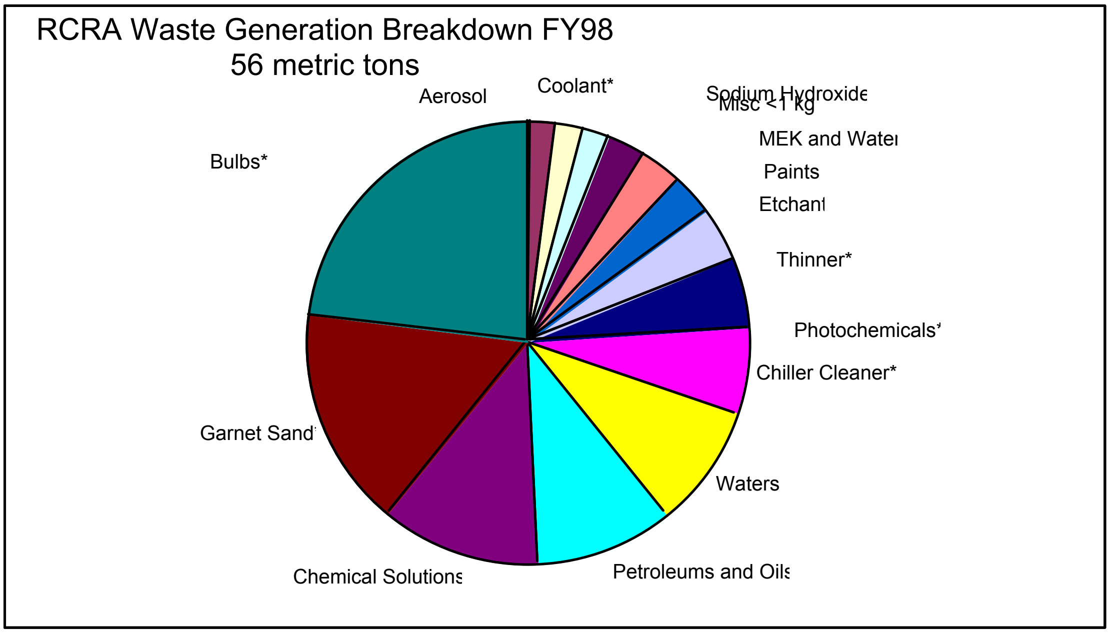


Fig. 5-4a. RCRA waste generation breakdown for FY98.

used by the Los Alamos Neutron Science Center (LANSCE); Computing, Information, and Communications Division (CIC); CST; NMT; and other groups with heat exchangers. The majority of this waste stream is recycled. Chiller cleaner frequently is spilled during cleaning operations, which generates spill cleanup waste.

Photochemicals* (2.5 tonnes): CIC and DX divisions are the predominate photochemical users. Much of this waste stream is recycled through the TA-50 RLWTF. With Laboratory conversion to digital photography, this waste stream will decrease.

Thinner* (2.0 tonnes): Thinner predominantly is used by JCNNM. A new system was installed in FY98 to recycle spent lacquer thinners.

Etchant (1.5 tonnes): This chemical compound used by the DX Division printed-circuit shop is the primary waste generator.

Paints (1.5 tonnes): Paints predominantly are used by JCNNM in support of Laboratory organizations.

MEK and Water (1.4 tonnes): DX Division dominated this waste stream in FY98. However, no waste was generated in FY97.

Generation of waste can also be broken down by division. This information is shown in Fig. 5-4b.

5.4. State Waste Breakdown

Approximately 196 tonnes of State waste was generated in FY98. The pie chart in Fig. 5-5a depicts the distribution of this waste type. Eighty percent of the waste streams will be described below.

Petroleum-Contaminated Soils (56.7 tonnes): This waste stream was dominated by spills of petroleum products onto soils. Fossil Energy (FE) Division was listed on the Chemical Waste Disposal forms as the main contributor to this waste stream in FY98. Petroleum spills originate with individuals (vehicles), Laboratory organizations, JCNNM, and subcontractors.

Contaminated Waters (51.8 tonnes): This waste stream includes process and spill waters contaminated with materials such as oils, grease, solids, solutions, ethylene glycol, and antifreeze. In FY98, 40% of this waste stream originated in P Division when collected storm waters were removed from TA-53 for P-2.

Oils (38.1 tonnes): Oils are used throughout the Laboratory, predominately in maintenance operations.

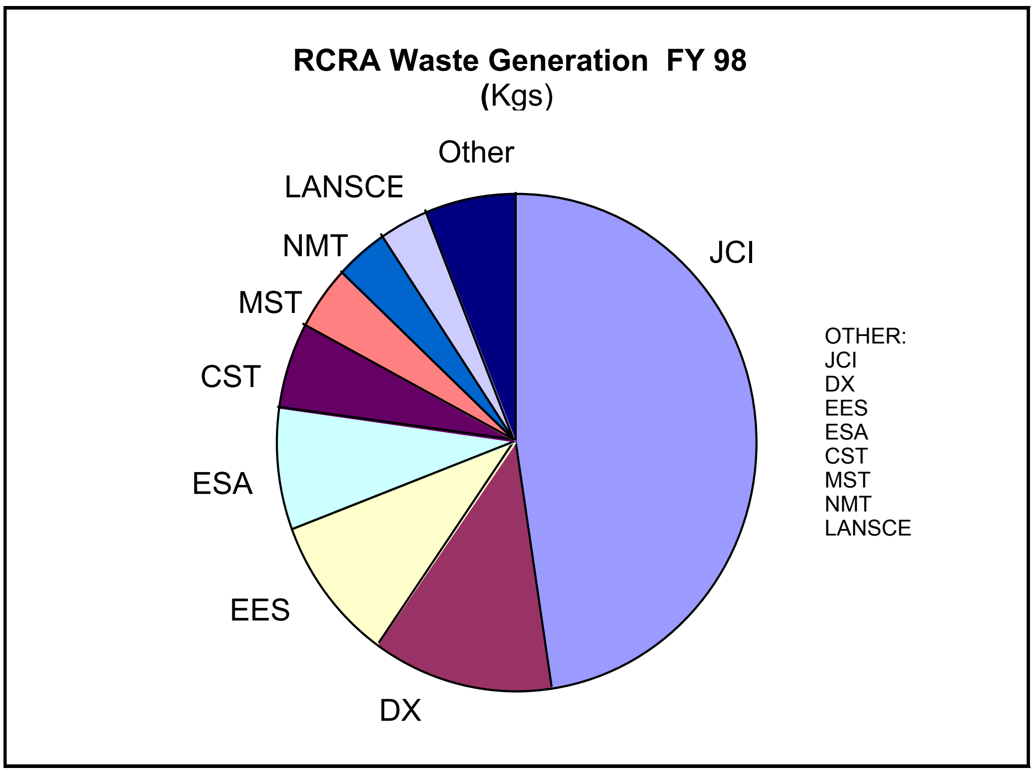


Fig. 5-4b. RCRA waste generation breakdown for FY98 by division.

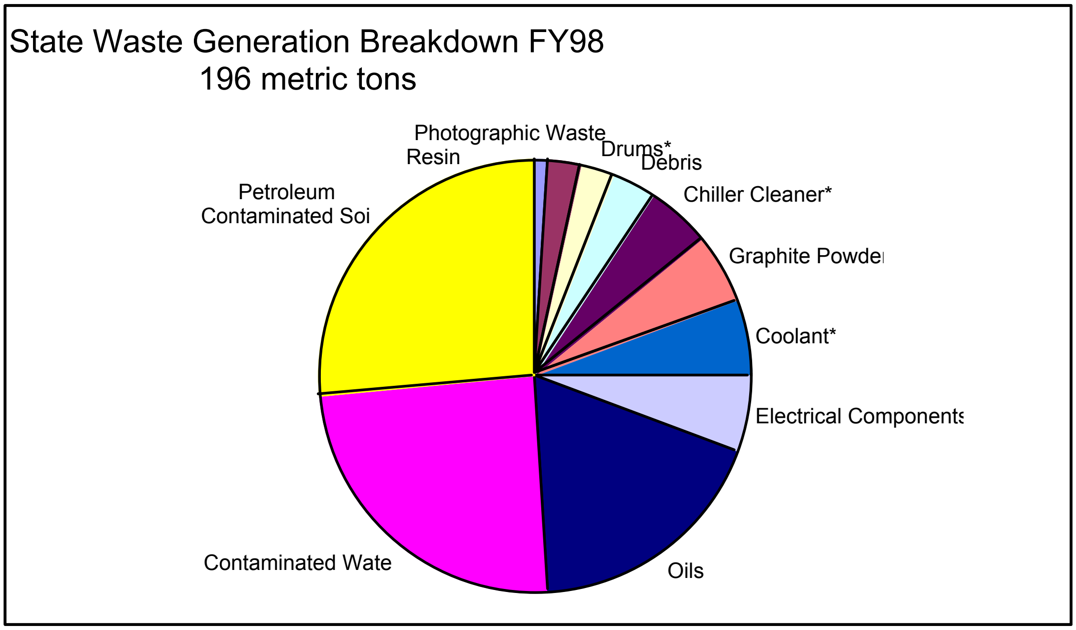


Fig. 5-5a. State waste generation breakdown for FY98.

Electrical Components (12.5 tonnes): Capacitors, electrical switches, transformers, power supplies, etc., are State waste. In FY98, this waste stream was dominated by LANSCE capacitors.

Coolants* (11.7 tonnes): Coolants are used at shops across the Laboratory in machining operations. At the ESA-WMM shop coolant, a large fraction of the total waste stream now is recycled on site.

Graphite (11 tonnes): In FY98, graphite residue was removed from the ductwork (Sigma complex). This waste did not recur in future fiscal years.

Generation of waste also can be broken down by division, as shown in Fig. 5-5b.

5.5. TSCA Waste Breakdown

Approximately 148 tonnes of TSCA waste was generated in FY98. The pie chart in Fig. 5-6a represents a breakdown of this waste stream. Eighty percent of the waste streams will be described below.

Sewage Sludge (68 tonnes): In calendar year (CY)95, LANL sanitary sewage sludge contained one sample that exceeded the regulatory limit for PCBs. Since then, sanitary sewage sludge has been disposed of as TSCA waste. The largest single constituent of the TSCA hazardous waste type is the PCB-contaminated sanitary sludges, which constitute 78% of TSCA wastes and 46% of all hazardous wastes at the Laboratory. These wastes occur because the sanitary sewer lines upstream of the wastewater plant have PCB contamination. There is also the possibility of PCB contamination from infiltration and inflow of rainwater into buried sewer lines. Surface-water inflow into these contaminated regions serves as a medium for migration of the PCBs. Because the

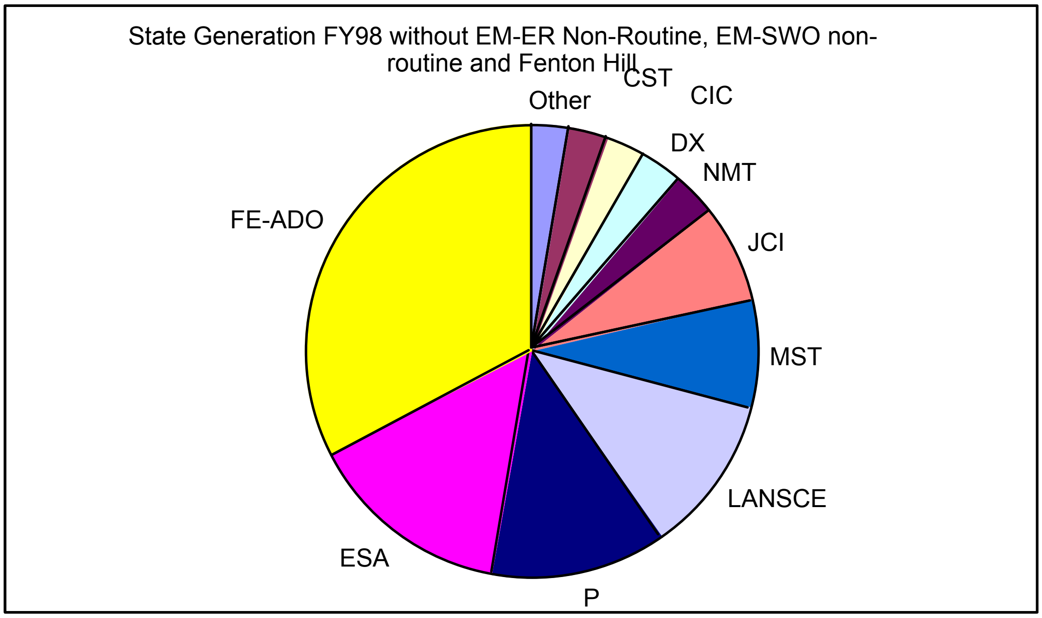


Fig. 5-5b. State waste generation breakdown for FY98 by division.

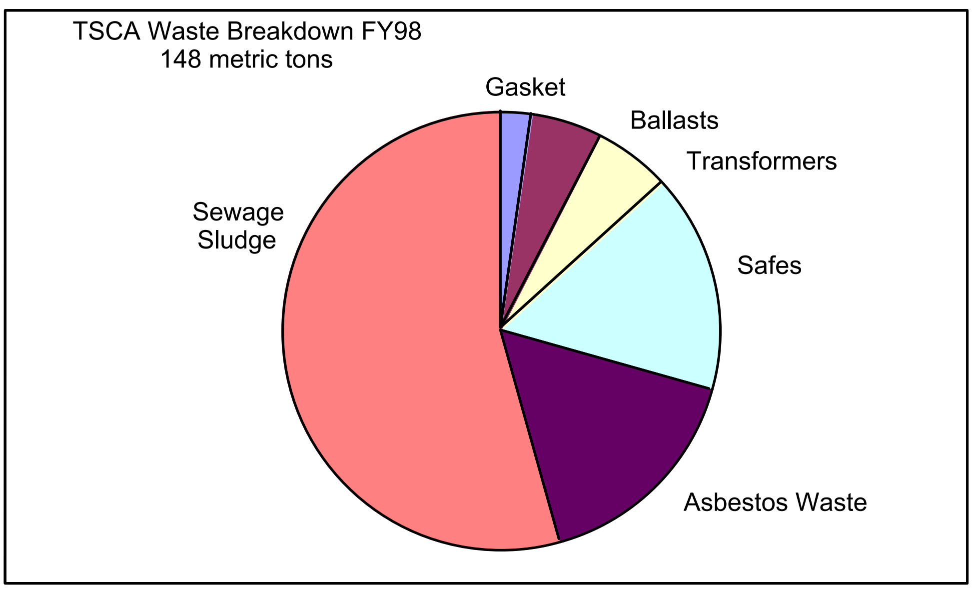


Fig. 5-6a. TSCA waste generation breakdown for FY98.

piping is old and undoubtedly breached at many points, the PCB-contaminated water enters the sanitary piping and contaminates the sanitary waste. As a result, the sludges produced by treatment of the sanitary waste are contaminated with PCBs and therefore are TSCA waste. These sludges are sent off site for incineration.

Asbestos Waste (20 tonnes). This waste stream is bagged for the removal of items containing asbestos or from cleanout of asbestos-contaminated facilities.

Safes (20 tonnes): Some older safes include asbestos insulation.

Transformers (7 tonnes): Transformers containing PCBs are being eliminated from use at the Laboratory.

Generation of waste also can be broken down by division, as shown in Fig. 5-6b.

5.6. Issues and Constraints

The following issues affect the hazardous waste stream.

1. PCB-Contaminated Sanitary Sludge. DOE, NMED, and Laboratory agreement is required to determine what must be done to convince all parties that the risk of exceeding the PCB limit has been addressed and that sludge can be land-applied as a soil builder, as has been done previously to sludges having a single high-PCB measurement.

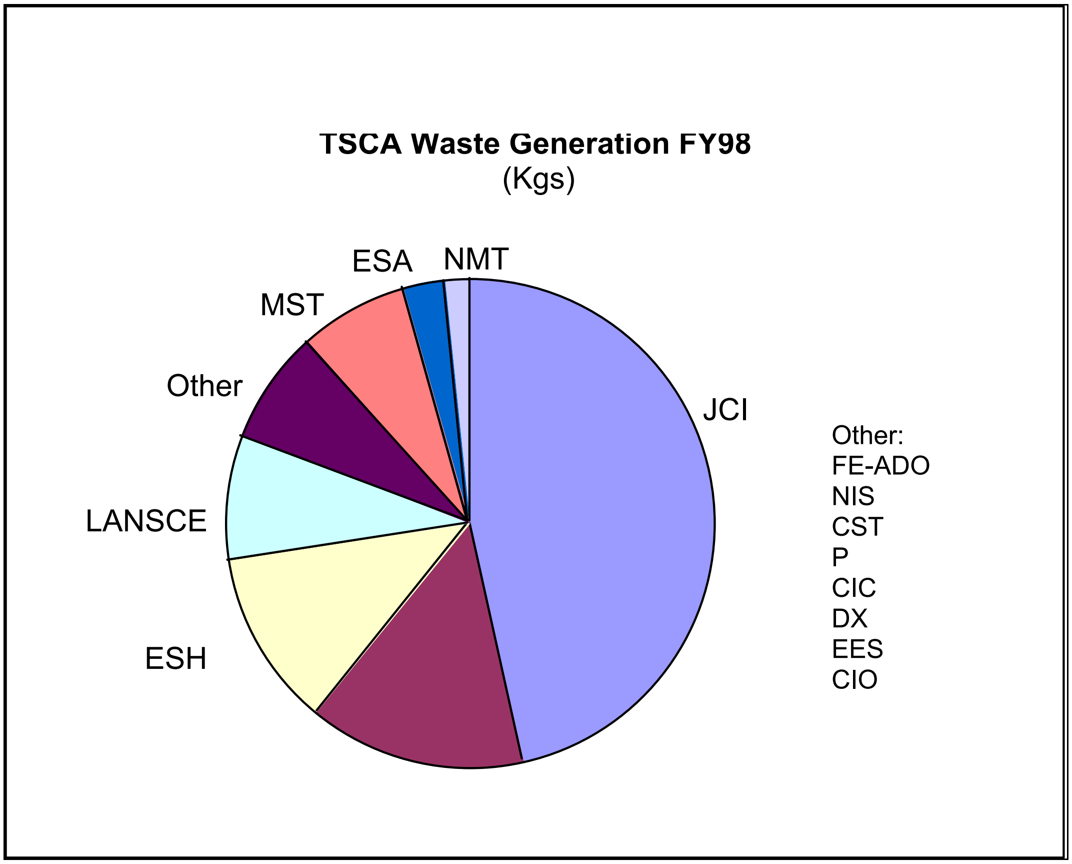


Fig. 5-6b. TSCA waste generation breakdown for FY98 by division.

2. Fluorescent Bulbs. Fluorescent bulbs currently are treated as RCRA waste. Therefore, all spent bulbs at the Laboratory are manifested as RCRA waste. Options are being explored for alternatives to handling the bulbs as hazardous waste because most bulbs are sent offsite for recycling.

3. Chemical Tracking. The current system of managing hazardous waste at the Laboratory is insufficient for tracking from beginning to end. To review the hazardous waste stream adequately for minimization opportunities, safety, compliance with authorization bases, etc., current Laboratory systems must be integrated to track chemicals from their arrival on site through their usage and disposal. The time and effort expended to track this information also must be considered. Using a chemical inventory group would be more efficient and money saving than asking principal investigators to inventory their chemical supplies. There are many databases and tracking systems in use at the Laboratory, including Just In Time (JIT) records, the Automated Chemical Inventory System (ACIS) database, and TA-54 records; however, none of these is used specifically for hazardous waste tracking. Some chemicals are bar-coded, whereas others are not if they are not purchased via

the JIT system. ACIS is used by only ~25% of the generators, and most generators keep their own databases to inventory their chemicals. Hazardous waste management and minimization would be facilitated greatly by a beginning-to-end integrated database.

4. Unused Chemical Exchange. The Laboratory does not have an efficient system for chemical exchange, especially for excess chemicals that may be able to satisfy mission needs elsewhere in the Laboratory. A physical chemical exchange system [the Chemical Exchange Assistance Program and External Recycle (CHEAPER) Program] was operating a few years ago but was discontinued because of a large buildup of excess chemicals and the cost of maintaining a physical inventory. The chemical tracking system described in #3 is essential to establishing an inventory-less exchange system.

5. *De minimus* RCRA Chemical Solutions, Waters, Chiller Cleaner, and Photochemical. Currently, the Sanitary Wastewater Consolidation System (SWCS) is not permitted to accept industrial waste. Therefore, waste is disposed of rather than treated in a wastewater treatment facility. For example, photochemicals used in a local, commercial, 1-hour photoprocessing facility are disposed of and treated via a municipal wastewater facility with a pretreatment program.

5.7. Waste Streams

Dividing the hazardous waste type into three components, RCRA, State, and TSCA, shows which waste streams dominate.

RCRA waste is dominated by fluorescent bulbs, garnet sand, chemicals, contaminated petroleum, oils, and waters. State waste is dominated by contaminated waters but also has petroleum-contaminated soils as a large component. TSCA waste is dominated by sanitary sewage sludge contaminated with PCBs. To put this in perspective, earlier figures showed pie charts dividing the waste stream of these three hazardous waste types. However, the same amount of waste is not generated in each category. Therefore, Fig. 5-7 combines all three waste types.

5.7.1. Fluorescent Bulbs

Fluorescent bulbs comprise 20% of the RCRA waste stream. Bulbs are hazardous because they contain 10 to 40 mg of mercury, both as a vapor and combined with some other material in a reservoir. These bulbs are used across the Laboratory in areas such as offices, warehouses, and experimental areas. The process map is shown in Fig. 5-8. Based on the lighting requirement, fluorescent, metal vapor, or incandescent lighting is designed and installed. A typical bulb lasts 15,000 hours (3 years). Spent bulbs are replaced by JCNNM, collected in a warehouse, and shipped to a recycler, who charges $0.56/4-ft tube. Typically, 100,000 bulbs are replaced each year. In previous years, bulbs were replaced on a schedule; however, with the advent of the facility management model, bulbs may be replaced on a schedule or on an as-needed basis. Bulbs in radiological control facilities can become mixed waste, either through activation or surface contamination. In addition, breaking a bulb in an RCA that processes actinides always results in MLLW generation. Because fluorescent lighting is very efficient, maximizing its appropriate use is part of the Laboratory's conservation strategy.

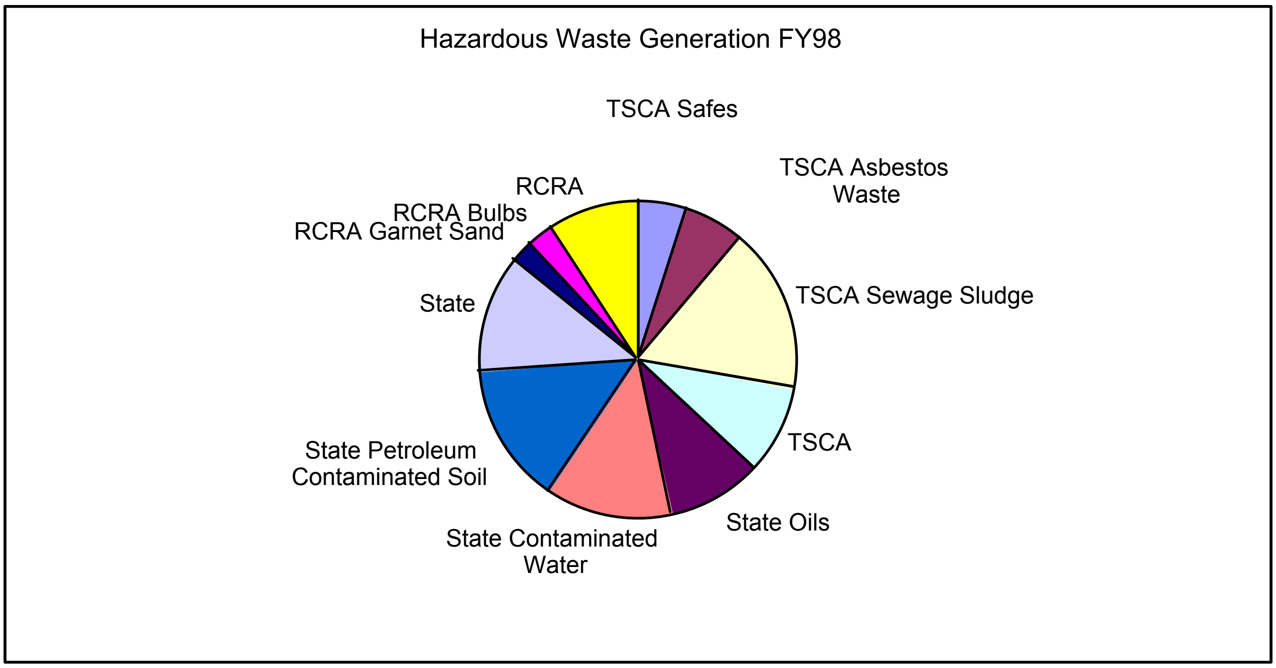
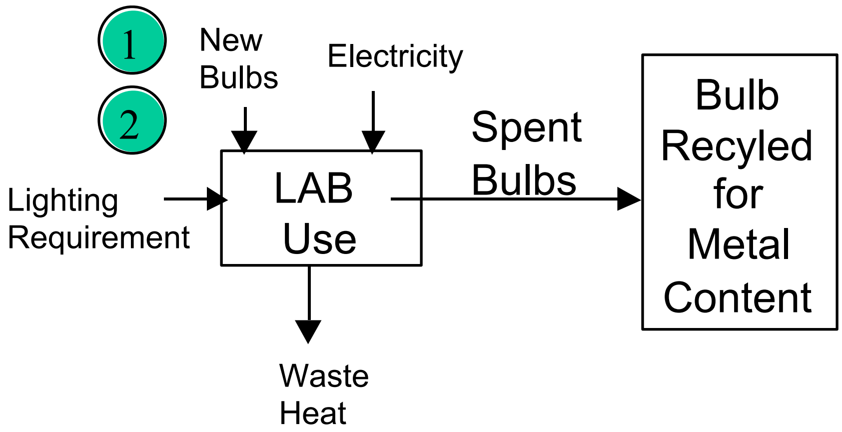


Fig. 5-7. Hazardous waste generation breakdown for FY98.

Waste minimization action taken to date:

JCNNM now exclusively procures Phillips Alto™ fluorescent bulbs (low-mercury bulbs that do not have to be disposed of as RCRA hazardous waste).



1. Buy green fluorescent bulbs unless not available.
2. Block purchase of hazardous bulbs in JIT Catalog.

Fig. 5-8. Process map for fluorescent bulbs.

5.7.1.1. Improvement Options

5.7.1.1.1. Option H1. Block procurement of any but nonhazardous fluorescent bulbs in the JIT procurement system and in procurement purchase orders. Although JCNNM purchases the majority of bulbs, facility management units and operating groups also buy bulbs. The hazardous waste stream can be eliminated (without requiring Laboratory personnel to be trained to select the nonhazardous bulb) by making it impossible to purchase hazardous bulbs (by making a special request to BUS-5). Cost: no additional cost because nonhazardous bulbs cost approximately the same as hazardous ones. Waste avoided: none. Bulbs already are recycled (for their metal content); however, there is considerable operational savings from avoiding the special handling these bulbs now receive. ROI: to be determined (TBD). Waste-avoidance type: material substitution. This option is programmed for implementation in FY99.

5.7.1.1.2. Option H2. Require Purchase of Non-RCRA Bulbs in Laboratory Subcontracts, Especially Construction Contracts. Cost: none. Waste avoided: not estimated. ROI: TBD. Waste-avoidance type: material substitution. This option is programmed for implementation in FY99.

5.7.1.1.3. Option H3. Design and Upgrade Facilities for Daylighting with Light-Sensitive Artificial Light Control. Many Laboratory facilities are used only during daylight hours and could be modified to take maximum advantage of daylight. By adjusting artificial lighting levels to achieve a constant light level throughout the day, annual operation hours for fluorescent bulbs can be reduced, thereby extending the time between bulb changeouts. Although this may be excessively expensive in existing facilities, it may be done for little additional cost in new facilities. As an additional benefit, daylight has been shown to reduce stress on workers and create a more productive work environment. Cost: TBD. Waste avoided: TBD. ROI: TBD. Waste-avoidance type: lifetime extension.

Performance Measures

- Number of RCRA fluorescent bulbs procured annually.
- Number of RCRA fluorescent bulbs disposed of annually.
- Fraction of Laboratory workspace estimated to be daylit within 10 years.

5.7.2. Petroleum Contaminated Soil and Absorbant Materials

Soils are contaminated with petroleum products from spills, leaks, and accidents at the Laboratory. Typically, spills happen during delivery and filling of oil-using equipment, equipment operation (leaks), and oil removal. Petroleum products include fuels (diesel, gasoline, etc.) and lubricating oils.

5.7.2.1. Improvement Options

5.7.2.1.1. Option H4. Soils Could Be Excavated and Inoculated with Bacteria for Breakdown of the Petroleum Constituents. This would eliminate the need to dispose of the material as hazardous waste and would avoid ~50 tonnes annually for a cost savings of $637,500. It is estimated that setting up a site to perform bioremediation would cost a minimum of $200,000 to treat this entire waste stream. Operations costs are unknown. Waste avoided: 50 tonnes. ROI: TBD. Waste-avoidance type: treatment. This option is under discussion for implementation in FY00.

5.7.2.1.2. Option H5. Enhance the Laboratory Spill Prevention Program with Contractual/Financial Incentives. This option includes contractual penalties for subcontractor spills (JCNNM, PTLA, and Aramark), spill bonding requirements for lower-level subcontractors, and recharging of spill costs to the spill site owner. Cost: unknown. Waste avoidance: probably significant. ROI: unknown. Waste-avoidance type: source avoidance.

5.7.2.1.3. Option H6. Conversion to Spill-Proof Fluids or Nonhazardous Bio-Oils That Do Not Require Cleanup. For some applications, propane can be substituted for diesel or gasoline fuels. Although conversion of existing equipment may not be cost effective, procurement of new propane-fueled systems may be very cost effective. The extra capital costs will be offset by lower operating costs because propane is a gas at ambient temperature and pressure. Soy-based bio-oils have been approved for several lubrication applications. These could be substituted into present equipment (with the manufacturer's approval). In addition, new equipment could be required to operate on nonhazardous oils. Cost: unknown. Waste avoided: unknown. ROI: unknown. Waste-avoidance type: material substitution.

5.7.2.1.4. Option H7. Present Use of Sorbent "Kitty Litter" Could Be Replaced with Use of Energy Recoverable Mats. These mats could be placed beneath frequent spill and leak areas. The mats/spills can be burned for their British thermal unit content. Cost: TBD. Waste avoidance: TBD. ROI: TBD. Waste-avoidance type: volume reduction.

Performance Measures

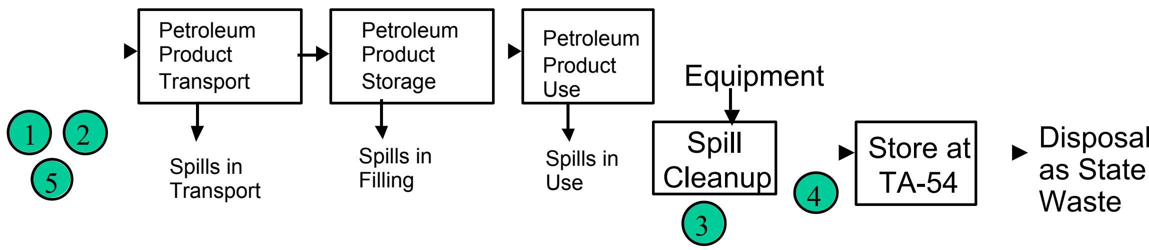
- Weight of petroleum-contaminated soil disposed of as hazardous waste.
- Number of petroleum spills reported annually.

5.7.3. Chemical Solutions, Photochemicals, Waters, Chiller Cleaner, and Etchant

Various aqueous wastes are generated that contain a non-RCRA hazardous chemical mixed with a large volume of water. These typically originate from industrial processes, maintenance activities, or accumulation in containment sumps. Photochemicals are produced in the development of photographs for publications and experiments. Various wastewaters come from containment sumps and various rinsing operations. Chiller cleaners are used for the heat exchangers at the Laboratory to remove scaling.

5.7.3.1. Improvement Options

5.7.3.1.1. Option H8. An Industrial Wastewater Plant Could Treat These Wastestreams if Permitted and Designed Properly. However, an easier way to implement this alternative is to purchase an industrial pretreatment unit. Currently, chiller cleaner, rinsewater, etc., are disposed of as hazardous waste, as seen in Fig. 5-9. By purchasing a mobile unit to treat these waste streams to meet the waste acceptance criteria of the sanitary waste plant, these materials may be treated at the SWSC plant as opposed to being disposed of as hazardous waste. See Fig. 5-10 for a listing of the treatment options appropriate for a small mobile treatment system. Purchase and setup of this unit would be approximately $100,000. Estimated waste avoidance would be 50 tonnes annually, for a costs savings of $638,000. Therefore, the ROI would be 600% in the first year, with continuing waste avoidance in subsequent years for the 20-year



1. Perform a Green Zia analysis of spills.
2. Work with JCNNM to develop a spill prevention plan.
3. In situ bioremediation for small spills.
4. Absorbent material energy recovery.
5. Require subcontractor spill insurance.

Fig. 5-9. Process map for spills.

lifetime of the pretreatment system. This option is programmed for implementation in FY99.

5.7.3.1.2. Option H9. Chiller Replacement. Modern chillers incorporate a continuous self-cleaning system (which circulates slightly abrasive sponge balls with the coolant). Modern chillers do not require chemical cleaning and its attendant waste generation. Although chiller replacement is a multimillion-dollar expense, the need to eliminate chillers using ozone-depleting substances (**Secretary of Energy memorandum dated December 12, 1998**) and the energy cost savings achievable with modern chillers and plate and frame heat exchangers make it very probable that most chillers requiring chemical cleaning will be replaced by 2005.

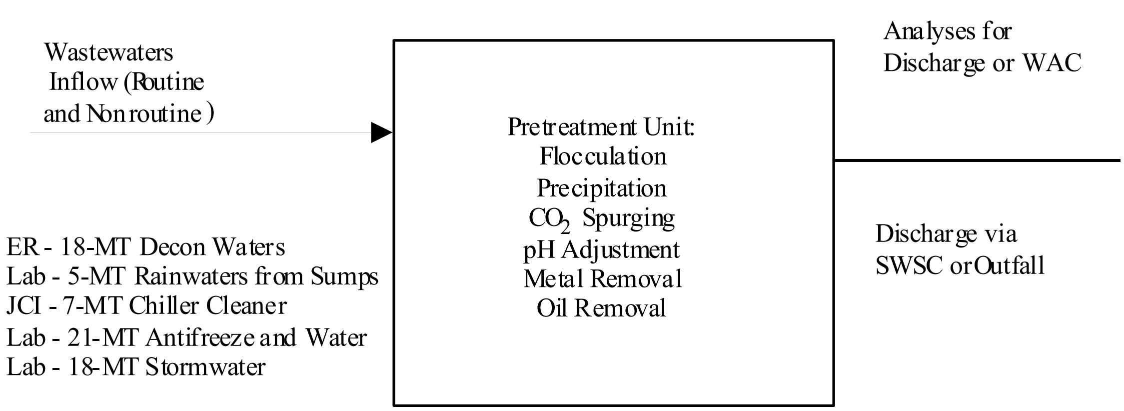


Fig. 5-10. Process map for treatment options.

Performance Measures

- Weight of liquid pretreated annually.
- Average cost of pretreatment per gallon.
- Weight of chiller cleaner purchased annually.

5.7.4. Garnet Sand

A water jet cutting system is used by JCNNM shops to cut metal objects for experimental testing. To achieve the precise dimensions required by the design specifications, garnet sand is used. However, when lead objects are cut, the sand is contaminated with lead, which is an RCRA waste. See Fig. 5-11 for the process map.

5.7.4.1. Option H10. Replacing Garnet with Another Abrasive That Binds the Lead Will Enable This Mixture to Pass the Toxic Characteristic Leaching Procedure (TCLP) Test for RCRA Waste. Although an alternative sand would have to be purchased, there is no cost to implement this project. Estimated waste avoidance would be 4 tonnes annually, for a costs savings of $51,000. Cost: minimal. Waste avoided: 4 tonnes annually. ROI: not applicable. Waste-avoidance type: material substitution.

Performance Measure

Weight of garnet sand recycled annually.

5.7.5. Machine Coolants

Machine coolants are a mixture of water-soluble oil (typically white) and other chemicals. Coolant is circulated continuously to cool cutting tools and other heat-generating parts. Over time, bacteria build up in the coolant, causing the solution to become acidic. This both reduces the effectiveness of the coolant and causes a possible health hazard. Most bacteria grow either under a layer of nonsoluble oil (on the surface) or on metal particles that circulate with the fluid.

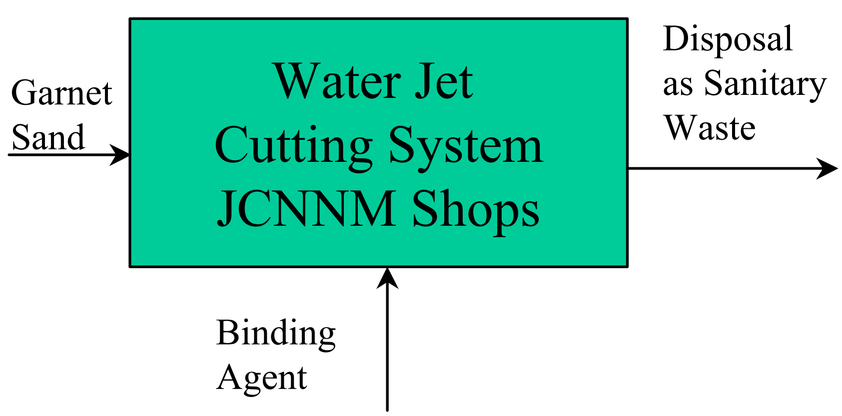


Fig. 5-11. Process map for garnet sand.

Waste minimization action taken to date:

Coolant recycling systems have been installed on most machines at the ESA-WMM shops. These employ a combination of oil skimming, filtration, testing, and treatment to maintain the coolant peak performance indefinitely, without the use of biocides. Oil skimming removes the oil from the coolant stream; filters keep the coolants free of metal fines; and tests are conducted to ascertain pH, water/coolant concentration, and degree of bacterial activity—based on the test results, the coolant can be treated to return it to a basic pH level, achieve optimal water/coolant concentration, and stop bacterial activity before it damages the coolant. This has eliminated 10 tonnes of coolant waste annually.

5.7.5.1. Improvement Options

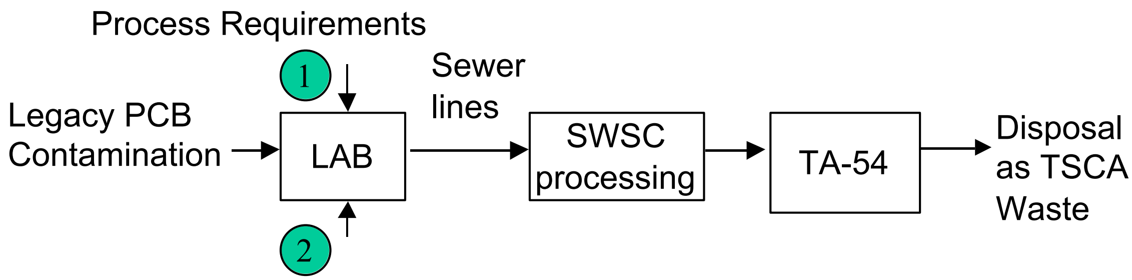
5.7.5.1.1. Option H11. Install Coolant Recycling Systems on the Remaining Machining Systems. Cost: $80,000. Funding source: WM upstream treatment project. Waste avoidance: State: 4 tonnes, for a cost savings of $51,000. ROI: 61% in the first year. The recycling system has a 10-year lifetime. This option is programmed for implementation in FY99.

Performance Measure

Weight of machine coolant disposed of annually.

5.7.6. PCB-Contaminated Sanitary Sludge from SWSC Plant

Sludge from the sanitary waste plant is disposed of as hazardous waste because of contamination with PCBs. Sampling upstream indicates that this contamination may be coming from four contaminated floor drains in the Sigma facility (see Fig. 5-12).



1 Eliminate inflow/infiltration of PCBs into sewer lines
2. Clean out suspect floor drains which contribute to PCB contamination.

Fig. 5-12. Process map for PCB-contaminated sludges.

5.7.6.1. Improvement Options

5.7.6.1.1. Option H12. A Plan Will Be Developed to Determine the PCB Sources Followed by Implementing the Necessary Measures to Eliminate the Sources. This will allow the sludge to be land-applied as opposed to disposed of as hazardous waste. Cost: $80,000 (estimated). Funding Source: WM upstream treatment project. Waste-avoidance type: TSCA 70 tonnes. ROI: 1100% in the first year. This option is programmed for implementation in FY99.

Performance Measure

Weight of sanitary sludge disposed of as PCB contaminated.

6.0. SOLID SANITARY WASTE

6.1. Definition

Most material brought into the Laboratory will leave as solid sanitary waste if it cannot be sold for reuse, salvage, or recycle. Sanitary waste is excess material that is neither radioactive nor hazardous and can be disposed of in the DOE-owned, Los-Alamos-County-operated landfill according to the waste acceptance criteria of that landfill and the State of New Mexico Solid Waste Act and regulations. Solid sanitary waste includes such items as paper, cardboard, office supplies and furniture, food waste, wood, brush, and construction/demolition waste.

6.2. Sanitary Waste System

Nonhazardous, nonradioactive materials purchased by, mailed to, or otherwise received by the Laboratory are used and discarded to the excess material, recycle, or sanitary disposal systems. These materials are managed as three different material streams:

1. For property-numbered and otherwise salvageable items, group property representatives process the material streams out of the Laboratory inventory system. JCNNM collects them and offers them for reuse/salvage through a DOE/General Services Administration (GSA)-mandated process that maximizes reuse. Nonsalvageable items are disposed of through JCNNM to the County Landfill.

2. Construction debris (soil, concrete, rubble, and asphalt) is disposed of by the construction contractor to the County Landfill (or elsewhere) or through JCNNM to the landfill. Currently, debris disposed of by a contractor is not included in the Laboratory's sanitary waste measures. Previously, JCNNM-disposed construction debris was reused as the roadbase for TA-3's new East Road Landbridge at the County Landfill; however, this landbridge was closed by the state NMED in early 1998 because of alleged improper material being included in the Landbridge Fill. The County has applied to remediate this and reopen the Landbridge to all previous materials except asphalt. It is uncertain when the State may respond to the County's submission.

3. Several excess commodities are reused on site (used asphalt, construction materials, etc.) or recycled off site (paper, junk mail, oil, and cardboard). Each waste stream has its own recycle system.

The process flow-map element for the sanitary waste type is shown in Fig. 6-1. The three major waste streams are shown, and the dumpster stream is broken down further.

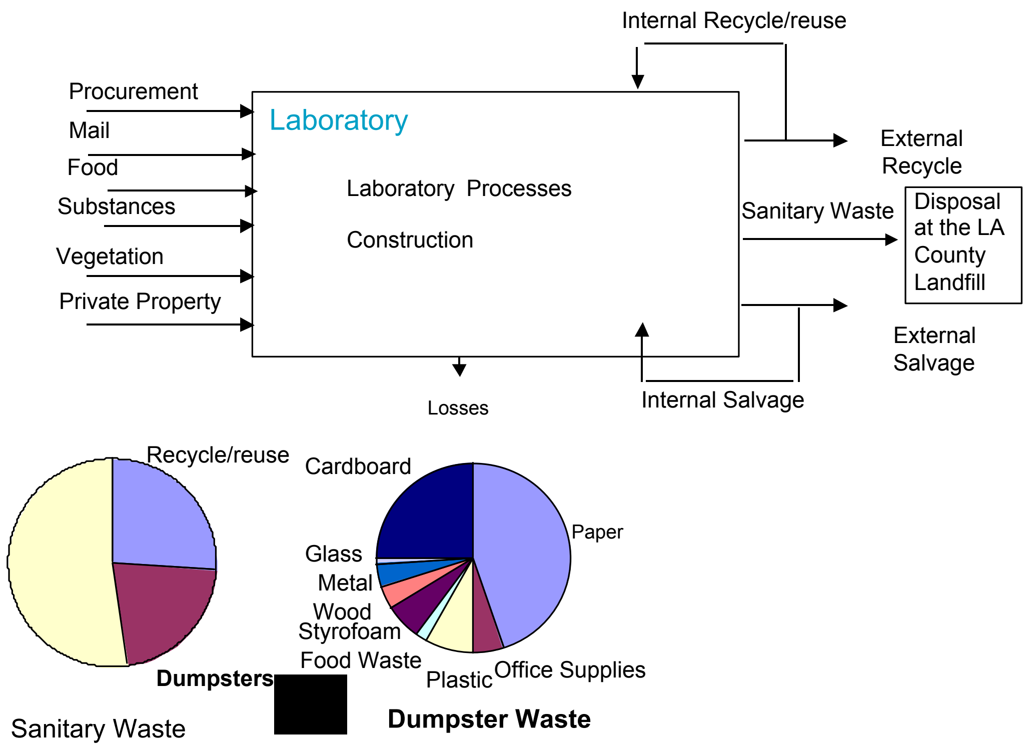


Fig. 6-1. Top-level solid sanitary waste process map.

The Laboratory generates more than 9500 tonnes of sanitary waste per year. The exact size of the waste streams and the year-to-year variation are difficult to assess because sanitary waste is not traced by generator or in detail by waste stream. The data are incomplete and have been updated from 1995 data.

Construction Waste (5000 tonnes): The largest sanitary waste stream is the construction/demolition stream. The stream consists mostly of dirt, used asphalt, and concrete from demolition or refurbishing activities. Of all of the material going to the landfill, ~5000 tonnes comes from construction or demolition.

Recycle/Reuse (2500 tonnes—Recycle Only): Items that have been replaced or are no longer needed but have some useful life left can be recycled. These items can be reused within the Laboratory or sold to individuals, organizations, or vendors off site for recycling. The size of this waste stream in metric tons is not known. Many items that have reached the end of their useful life can be recycled. The Laboratory currently recycles ~2500 tonnes of material.

Dumpster Waste (2000 tonnes): This waste stream consists of items discarded in waste bins and other receptacles around the Laboratory. It is made up of paper, cardboard, glass, plastic, styrofoam, wood, food items, office supplies, and metal. The dumpster material breaks down into the following waste streams (as shown in Fig. 6-2):

Dumpster Waste Stream	Percent
Paper	45
Office Supplies	5
Plastics	8
Styrofoam	2
Food Waste	6
Wood	4
Metal	4
Glass	1
Cardboard	25

Fig. 6-2. Dumpster waste streams.

The cost of collecting and disposing of dumpster waste is $134.54/tonnes. The cost of construction waste disposal is not accurately known. Dumpster pickups are not tracked to specific generators but are tracked at the Facility Management Unit (FMU) level. Estimated yearly dumpster pickups by the FMU are shown in Fig. 6-3.

6.3. Issues and Constraints

There are six major issues affecting sanitary waste.

1. The estimated lifetime of the County Landfill is 10 years.

2. Construction/demolition waste volumes are growing as the mission of the Laboratory changes and deconstruction and decommissioning operations increase.

3. Improved low-level and hazardous waste segregation procedures will demonstrate that a significant fraction of those waste types is really solid sanitary waste. **These procedures** will increase the total amount of such waste.

4. Each September, Laboratory projects with excess funding that will be lost at the end of the fiscal year purchase significant amounts of material more to avoid losing the funding than because they need the material.

5. The process of collecting, recycling, salvaging, and disposing of excess material (some of which becomes sanitary waste) is fragmented, expensive, and inefficient.

6. The most effective means of reducing solid sanitary waste is to minimize the volume materials purchased by the Laboratory; however, this must be done without interfering with the Laboratory's ability to accomplish its missions.

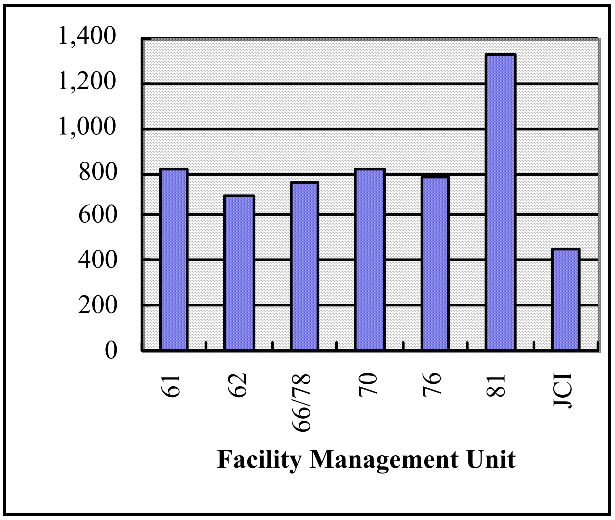


Fig. 6-3. Number of annual dumpster pickups for facility management units.

6.4. Sanitary Waste Streams

The relative size of the three principal waste streams, in metric tons, is shown in Fig. 6-4.

6.4.1. Construction/Demolition Waste

The largest sanitary waste stream is the construction/demolition stream. The stream consists mostly of dirt, used asphalt, and concrete from demolition or refurbishing activities. This waste stream currently is growing and will continue to grow as currently planned new construction and renovation projects begin (see Fig. 6-4).

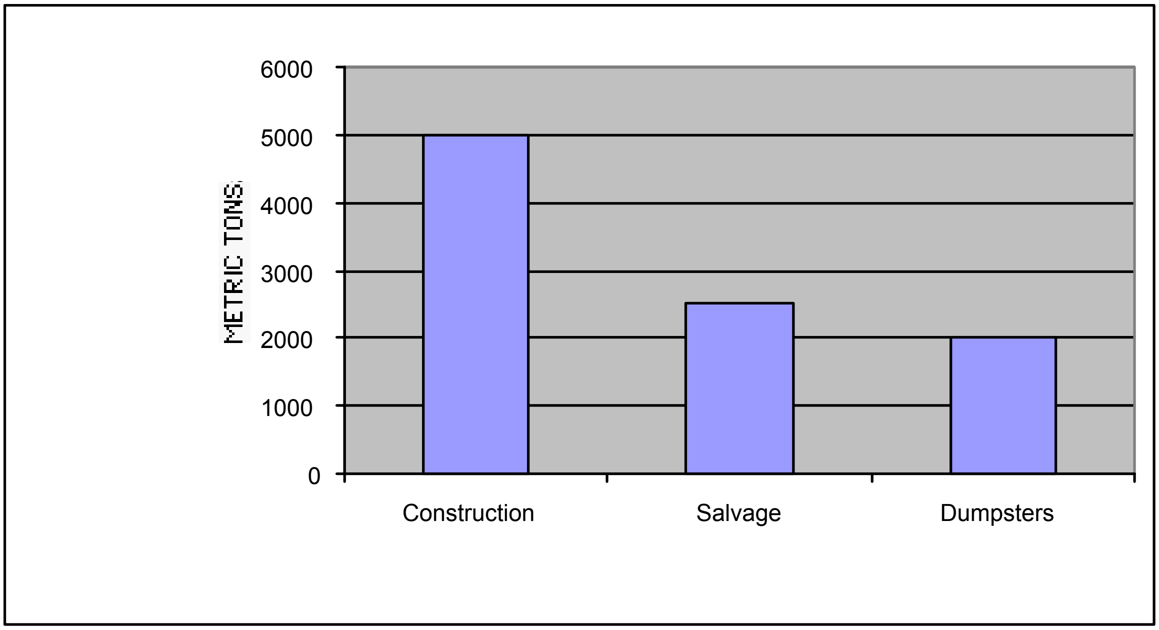


Fig. 6-4. Pareto analysis of solid sanitary waste streams.

Construction/demolition waste is generated during the Laboratory's projects to build new facilities, upgrade existing facilities, or demolish facilities that are no longer needed. The waste generated by these projects is varied and consists primarily of dirt, concrete, asphalt, wood items, and various metal objects. Currently, most of this waste goes directly to the landfill. The process flow map is shown in Fig. 6-5.

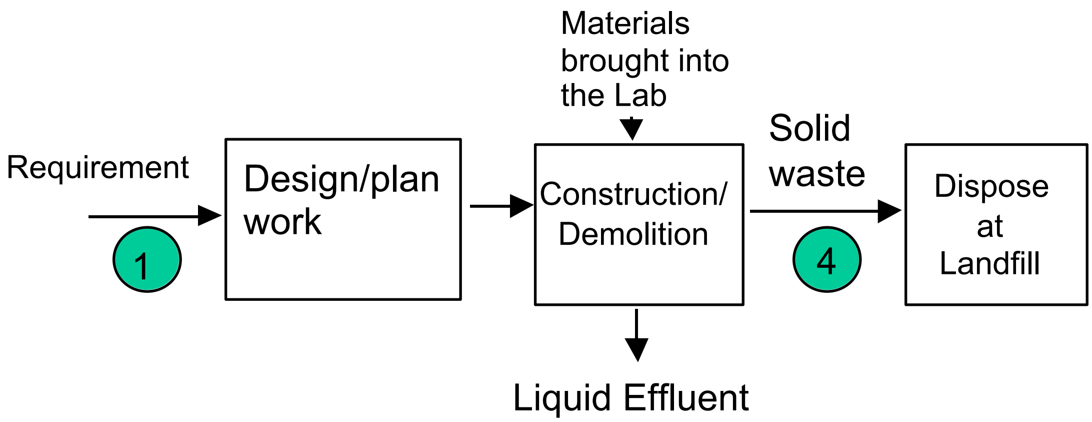
6.4.1.1. Improvement Options

6.4.1.1.1. Construction Contract Provisions. Construction contract provisions should encourage waste avoidance and recycling in all construction projects. JCNNM construction projects should be required to include waste costs in their bid. Waste-avoidance type: source reduction.

6.4.1.1.2. Concrete/Asphalt/Dirt Reuse. Because construction waste is the largest sanitary waste stream, reuse of construction/demolition debris will have a large effect on the waste volume. Reuse of noncontaminated asphalt is currently possible if the asphalt can be segregated from the other debris. Dirt for fill use also would reduce the volume of debris going to the landfill but may require storage for some period before use. Similarly, concrete rubble could be crushed for use as an aggregate or base course. There are several options for the reuse of construction/demolition debris. Waste-avoidance type: internal recycle.

6.4.2. Recycle/Salvage

Items that have been replaced or are no longer needed but have some useful life left can be sent to salvage. These items can be reused within the Laboratory or sold to persons,



1 - Design new construction for pollution prevention and waste minimization
- Plan demolition/rework for pollution prevention and waste minimization

4 - Concrete/asphalt/dirt reuse

Fig. 6-5. Construction waste stream process map.

organizations, or vendors off site. The size of this waste stream in metric tons is not known. Many items that have reached the end of their useful life can be recycled. The recycle market for paper, cardboard, and metal items is relatively good. There is no existing path for recycling plastic, styrofoam, and glass.

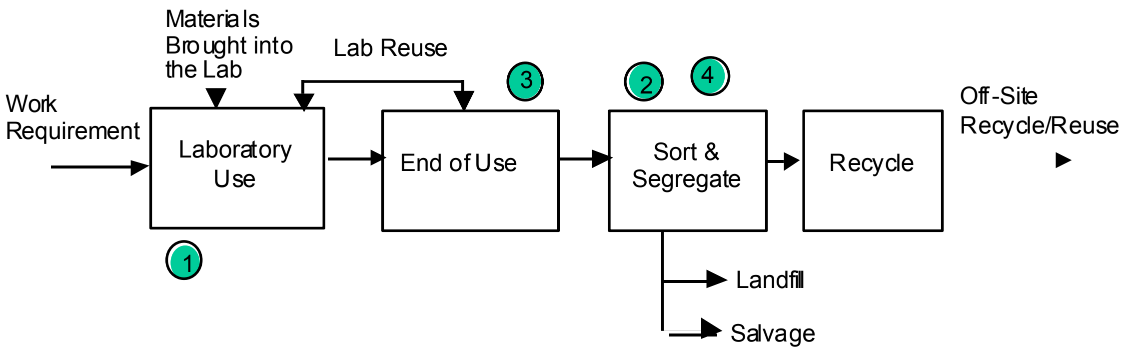
The Laboratory currently has successful recycling and salvage programs. The emphasis in this area is to expand these programs by making salvage items easier to use and by facilitating the recycling of used items. The recycling and salvage process flow-map elements are similar but have important differences. Therefore, both are shown in Fig. 6-6.

6.4.2.1. Improvement Options

6.4.2.1.1. Many procedural or policy changes can be implemented to improve recycle/reuse (see Fig. 6-7). These include a contracting provision for suppliers and subcontractors to pick up and recycle cardboard and paper packing materials, a lease instead of purchase, and an upgrade instead of replacement. Practices such as elimination of glue-bound documents and custodial pickup of recycle materials also will facilitate recycling. Waste-avoidance type: source avoidance.

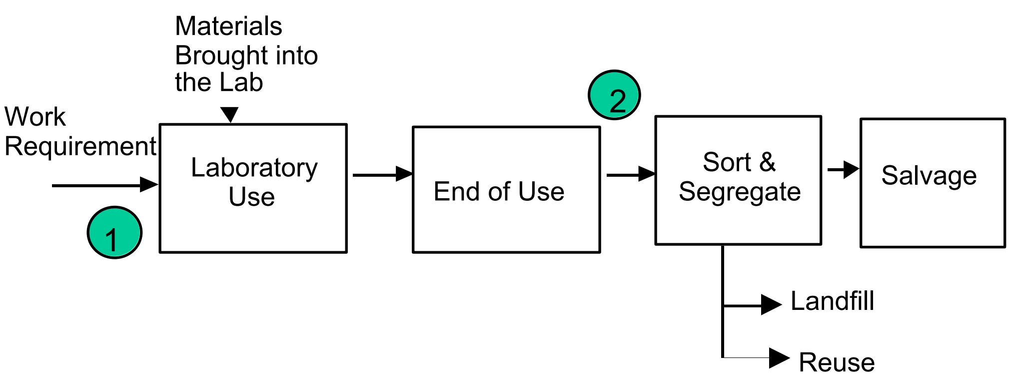
6.4.3. Salvage

The Laboratory currently has a successful salvage program. The emphasis in this area is to expand this program by making identification, procurement, and use of salvage items easier. The recycle and salvage process flow-map elements are similar but have important differences. Therefore, they are shown in separate process maps. The size of the salvage waste stream currently is not known.



1 Ê- Implement procurement policies that minimize generation of paper and
ÊÊÊÊÊcardboard waste
- Lease instead of purchase
- Upgrade instead of replace
- Eliminate glue-bound documents
- Arrange custodial pickup ofr ecycle items
2 - Build and operate a Materials Recovery Facility (MRF)
3 - Use of clear trash bags to facilitate sorting
4 - Segregate food waste

Fig. 6-6. Recycle/salvage process map I.



1- Implement procurement policies that maximize salvage potential
(repair or upgrade rather than dispose) ÊÊÊÊÊÊ
2- Implement on-line salvage system

Fig. 6-7. Recycle/salvage process map II.

6.4.3.1. Improvement Options

6.4.3.1.1. Purchase of Easily Repairable Items. Amend procurement policies to encourage purchase of easily repairable items such as furniture. Product lines that are designed for ease of repair are available. Waste-avoidance type: source reduction.

6.4.3.1.2. Increase the Reuse of Salvage Items. To increase the reuse of salvage items within the Laboratory, it should be as easy to order a salvage item as it is to order a new item. If a web-accessible salvage catalog with on-line ordering were established, reuse of salvage items would be easier. Waste-avoidance type: internal recycle.

6.4.4. Dumpster Waste

This waste stream consists of items discarded in waste bins and other receptacles around the Laboratory. The stream comprises paper, cardboard, glass, plastic, styrofoam, wood, food items, office supplies, and metal. Many of the items, such as paper and cardboard, could be recycled if they were segregated from the rest of the waste. Many of the nonrecyclable items, such as plastic and styrofoam, could be compacted and baled to minimize the landfill volume.

Dumpster waste consists of various items but is dominated by paper and cardboard, which make up 70% of the total volume. The quantity of the other items that make up dumpster waste is shown in Fig. 6-8.

Currently, all dumpster waste goes to the County Landfill. The process flow-map element for dumpster waste is shown in Fig. 6-9.

6.4.4.1. Improvement Options

6.4.4.1.1. Process Improvements. Many process and procedure improvements would decrease the quantity of waste going to the dumpster waste stream. These improvements include using MS A1000 for the disposal of unwanted paper waste, expansion of electronic publishing, and the implementation of procurement procedures that require suppliers and subcontractors to take back and recycle packing and extraneous paper materials.

6.4.4.1.2. Material Recovery Facility. Build and operate a materials recovery facility. The operation of a facility to aid the sorting and segregation of dumpster waste could have a large impact on the sanitary waste type and could facilitate expansion of the recycle/reuse program at the Laboratory. At such a facility, waste would be segregated into recyclable and nonrecyclable forms. It is anticipated that recycling of the two major categories of dumpster waste, paper and cardboard, could be increased dramatically. It is probably necessary to segregate food waste before sorting the nonfood waste. This process could be beneficial because alternate methods of dealing with food waste, such as composting, could be considered. The construction and operation of a metal recovery facility (MRF) would lead to recycling of the paper and cardboard components of dumpster waste. Because these components make up 70% of the waste going to the landfill, the effect on reduced volumes would be substantial and this waste stream would be greatly reduced. Waste-avoidance type: external recycle.

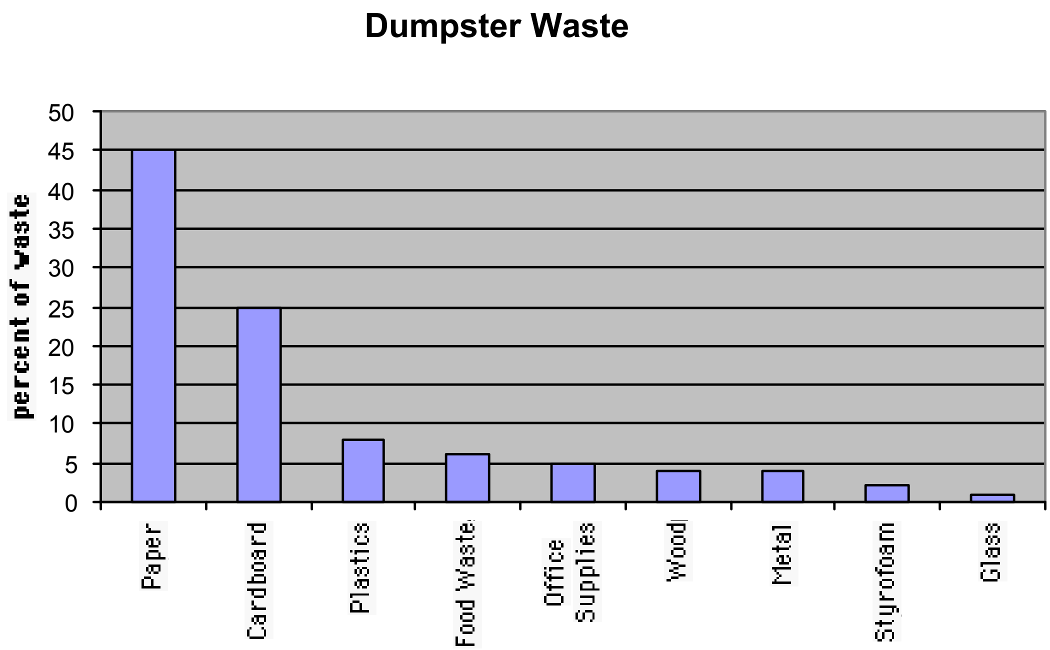
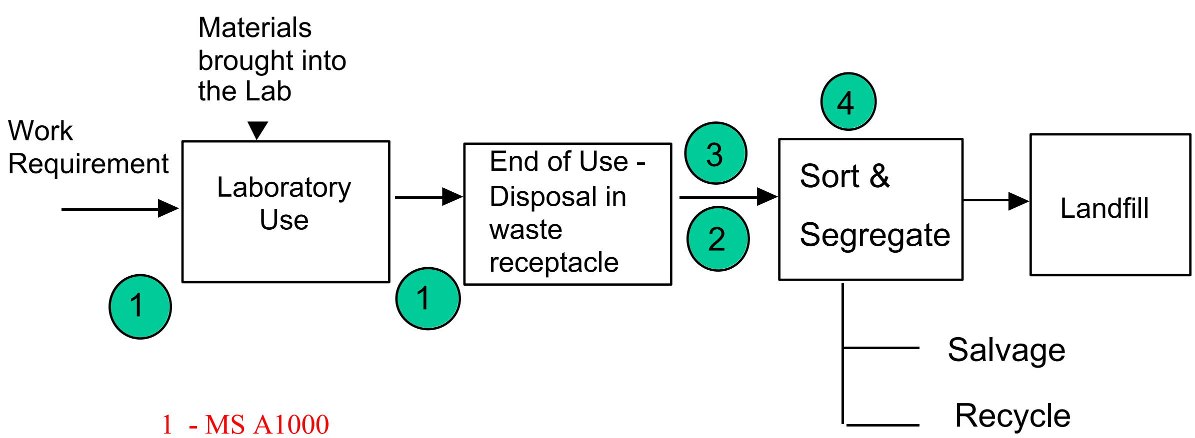


Fig. 6-8. Pareto analysis of dumpster waste streams.



1 - MS A1000
- Junk mail stop calls
- expand electronic publishing
- Implement procurement policies that minimize generation of paper & cardboard waste

2 - Build and operate a Materials Recovery Facility (MRF)

3 - Use of clear trash bags to facilitate sorting

4 - Segregate food waste

Fig. 6-9. Dumpster waste process map.

7.0. OTHER MATERIAL AND ENERGY FLOWS

Five additional areas require detailed analysis: energy, water, effluents, and emissions; ecosystem impact; regional environmental impact; construction; and the Environmental Restoration Project. Energy, water, effluents, and emissions are combined with water to form the “utility subsystem.” This is a typical material/energy flow and will be analyzed in the same manner as the waste flows described earlier in this document. Ecosystem and regional environmental impact will require different analysis methodologies, perhaps similar to those being used by the natural resources trustees. Construction and the ER Project are Laboratory subsystems that are relatively uncoupled from the main Laboratory operations. They require a separate analysis that focuses on their unique aspects and treats them as separate systems. These additional areas will be analyzed in the 1999 version of the Stewardship Roadmap.

8.0. SUMMARY AND THE PATH FORWARD

The Environmental Stewardship Program supports the Laboratory's goals of zero environmental incidents and zero RCRA violations through operations' improvements that eliminate the source of incidents and violations. These sources are waste, pollution, natural resources wastage, and natural resources damage. The Stewardship Program has taken a systems approach to eliminating these sources that are summarized in this Stewardship Roadmap document. The roadmap identifies recent waste minimization, pollution prevention, and conservation successes, as well as many improvement options now being implemented or that will be proposed for implementation. It also identifies performance measures that will track the impact of the improvement options. It is the nature of roadmaps that more options are identified than need to be pursued to achieve the endstate. The 1999 Roadmap will begin the process of prioritizing options. Over the next 5 years, this Stewardship approach should eliminate the sources of environmental incidents and RCRA violations from present operations.

The path forward must address institutionalization of Environmental Stewardship into Laboratory culture and the management framework. The roadmap described here is corrective in nature; it fixes the environmental aspects and impacts of present operations. It neither anticipates nor prevents future environmental aspects. Planning good Environmental Stewardship into future operations will require an Environmental Management System (EMS) (similar, but not necessarily identical to, ISO 14,001). An EMS would formally integrate pollution prevention, waste minimization, and conservation into Laboratory planning and would require objective-based continuous improvement of present operations. The NMED has recently announced a voluntary Environmental Excellence Award Program, built on pollution prevention, which requires that organizations establish an EMS. Pursuing this award would increase statewide awareness of environmental improvements already accomplished, establish a framework for implementing an EMS, and build the Laboratory's partnership with the NMED.

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